AERO ENGINEERING

VOLUME III

PART 2

Pages 433—872

AERO ENGINEERING

A COMPREHENSIVE WORK FOR THOSE ENGAGED IN THE PRODUCTION, ASSEMBLY, TESTING, MAINTENANCE, AND OVERHAUL OF AIRCRAFT

Advisory Editor :

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PUBLISHER'S NOTE

For greater convenience of readers each volume of this Work has in this edition been bound in two parts. The paging and treatment run consecutively throughout each volume.

The Index to the complete Work will be found at the end of Volume III.

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Tail Wheel Unit

The following additional information is given with regard to the fitment of new shock absorber rubbers and for adjustments during service.

To Fit New Rubbers

1. Remove fork complete with wheel from the main shock absorber unit.

2. Remove top centre nut of shock absorber unit and withdraw the inner sub-assembly.

3. Remove top fitting of inner sub-assembly which is attached of set screws.

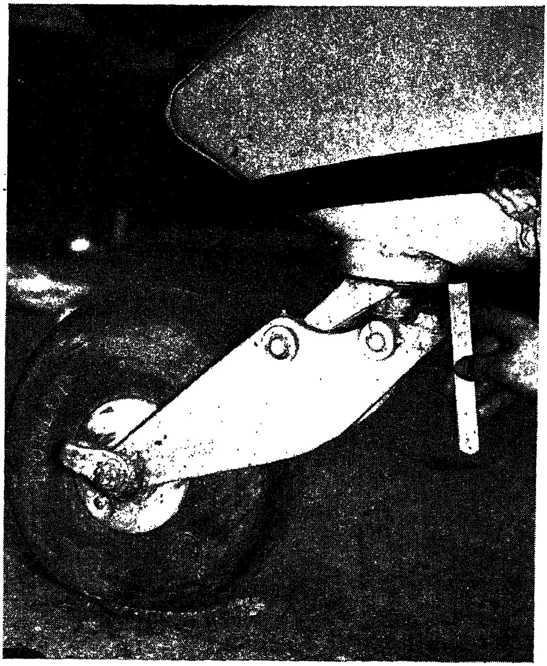


Fig. 39.—CHECKING DEFLECTION OF TAIL WHEEL SHOCK ABSORBER.

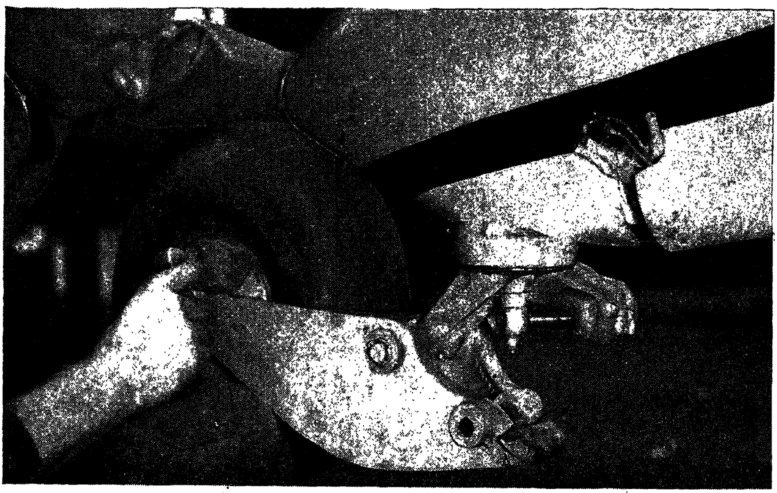


Fig. 40.—TAIL WHEEL SHOCK ABSORBER.
" Adjusting tension rod to take up settling of rubbers."

4. Unscrew centre tension rod when old rubbers with spacers can be removed.

5. Re-assemble with new rubbers with spacers in position.

6. The centre tension rod should then be screwed up until the rubbers are slightly compressed. The whole unit is then re-assembled.

With the aeroplane empty and standing on the tail wheel the rubbers will compress and when newly assembled show a gap of approximately $\frac{5}{8}$ in. between the bottom edge of the lower end fitting and the rubber stop block on the fork. If this dimension is not attained, the centre tension rod should be adjusted accordingly. During service this gap will naturally increase to approximately $1\frac{1}{2}$ in. due to the settling down of the rubbers. A proportion of this settling down can be taken up by a later screwing up of the centre tension rod. This adjustment, however, must not be continually made if the resiliency of the rubbers has been lost due to continual service or age; in this case the rubbers should be renewed.

MAINTENANCE & RECONDITIONING OF MICA SPARKING PLUGS

IT is of vital importance that the cleanliness and condition of sparking plugs be attended to both from an external and internal aspect if the engine is to give its best performance under all conditions and loads. The useful life of a sparking plug can be considerably lengthened by regular maintenance.

Routine Maintenance

Sparking plugs must be removed from the cylinders by the special spanners supplied for the purpose. On certain radial engines long tube spanners are provided, together with a long tommy bar, by means of which considerable leverage can be obtained. Open-jawed spanners should not be used, as these are liable to exert a side thrust on the sparking plug, which may possibly damage the body at the root of the thread. Similar damage can be caused by a tube spanner not being used in correct alignment with the plug.

Long-reach sparking plugs are usually more difficult to remove from the cylinder than short-reach sparking plugs, but no damage should result if reasonable precautions are taken during removal. If a slight seizure should occur between the threads of the sparking plug and the cylinder, application of paraffin will facilitate its removal from the cylinder. Under no circumstances should a hammer be used to assist removal. A sparking plug should not be re-fitted to the cylinder unless the threads are in good condition. The threads should be slightly smeared with graphite grease before entering in the cylinder; this will prevent seizure. In addition, the copper or copper-asbestos washer must be in good condition.

Before cleaning, the sparking plug should be carefully examined for loose or badly burnt electrodes, cracked body, particularly at the roots, or loose mica washers. Such plugs should not be cleaned, but placed on one side for reconditioning.

Dismantling

A jig, similar to that shown in Fig. 1 should, if available, be used together with a stock, Fig. 2. The dies for use with a stock of this type have hexagonal centres to suit varying types of plugs. The gland nuts of the sparking plug should in no circumstances be gripped in a vice, as this would distort it, and in addition the anti-corrosive coating would be damaged.

The hexagon on the body of the sparking plug should be inserted in the appropriate hole in the jig and the gland nut removed with the

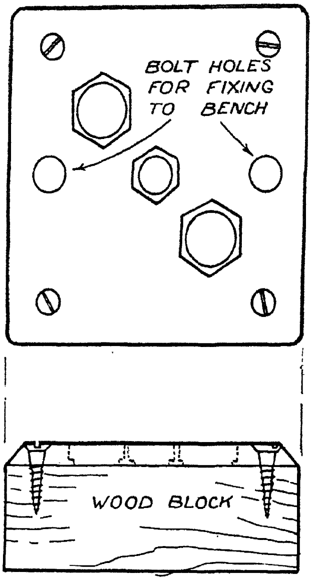


Fig. 1.—DISMANTLING JIG.
The wood block is cut away to allow the sparking plug to enter.

stock and correct die. Certain types of sparking plugs, for instance those which have a flange below the hexagon, have to be dismantled by inserting the hexagon of the body into the stock with the terminal downwards and then inserting the gland nut, which protrudes below the stock, into the jig.

Cleaning the Sparking Plug Central Electrode

When dismantled, the sparking plug centre must be cleaned with petrol and a soft rag; any hard deposit should be removed by using a special brush. Care must be exercised during this operation to obviate scratching or cutting the mica insulation. After cleaning the sparking plug centre, it should be polished with a soft rag which should be kept for this purpose.

On certain types of sparking plugs the insulation consists of stepped mica wrappings which are liable to flake; special care is necessary when cleaning these types. The nut holding the mica washers in position at the top of the central electrode must not be moved on any account.

The point of the central electrode should be cleaned if burred or pitted; these flaws should be removed by the use of emery paper.

Cleaning the Sparking Plug Body

The body of the sparking plug, which is the earth electrode, should be soaked in petrol and the carbon deposit removed. Examination for cracks, damaged threads, etc., should be made during this process. Any burring or pitting should be removed with emery cloth.

Assembly

New copper washers should, if necessary, be used when re-assembling the sparking plugs, and the centres must be replaced in their original bodies. The gland nut should be sufficiently tight to ensure gas-tightness,

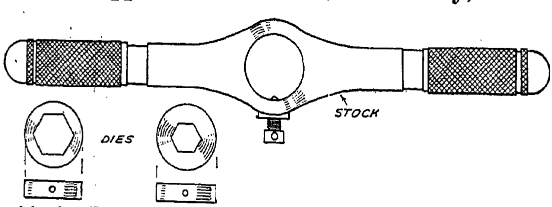


Fig. 2.—DIES AND STOCK FOR USE WITH DISMANTLING JIG.

but care should be taken when using the jig not to screw the gland into the body too tightly.

Setting the Gap

The sparking plug gap, that is the distance between the central electrode and the earth electrode, must be maintained correctly. The gap varies between 0·012 and 0·016 in. and is, if necessary, adjusted either by rotating the central electrode or bending the earth electrode ; this depends upon the type of sparking plug being cleaned. Under no circumstances should the central electrode be bent in order to obtain the correct adjustment.

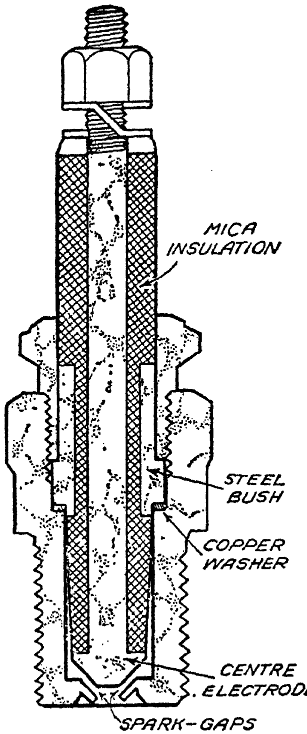


Fig. 3.—SECTION THROUGH TYPICAL SPARKING PLUG.

Drying

Before inserting the sparking plug in the tester, action must be taken to dry out those sparking plugs which have been washed in petrol. Failure to take this necessary precaution has caused accidents, due to the petrol and air mixture burning and the subsequent high pressure blowing out the glass observation window in the tester. The wiping of the separate parts before assembly is probably the most satisfactory method.

Electrical Tester

A type of sparking-plug tester is shown in Fig. 4. This type consists of :—

(*a*) An air chamber.
(*b*) A pressure gauge.
(*c*) A magneto.

Air Chamber

This chamber has a number of triplex glass observation windows on one side, and opposite, on the other side of the chamber, are apertures screwed internally to take the largest size of sparking plug, suitable adaptors being used for testing sparking plugs of smaller size.

Dummy plugs are also available for use should only one or two sparking plugs require testing.

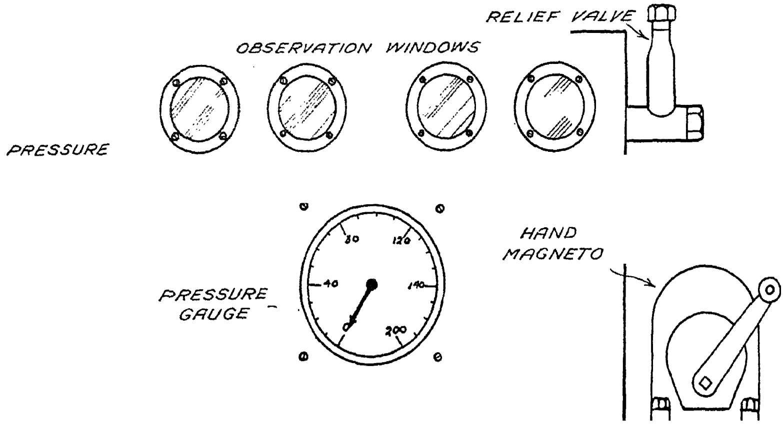


Fig. 4.—SPARKING PLUG TESTER.
This consists of an air chamber, pressure gauge and magneto.

The chamber is fitted with an air valve of suitable type for the attachment of a pump. This may be either a motor-driven compressor or an ordinary foot pump.

Pressure Gauge

A pressure gauge which will register from 0 to 200 lb. per sq. in. is connected to the air chamber and mounted in such a position that the operator can read it while using the magneto and observing the sparking plugs which are under test.

Magneto

A hand-operated magneto is mounted in a convenient position near the air chamber. High-tension leads fitted with suitable quick-release adaptors are fitted.

Testing

All sparking plugs, after being cleaned, should be tested under a pressure of 100 lb. per square inch ; during test they must spark regularly. Copper and asbestos washers must be used on the sparking or dummy plugs when screwing them into the tester.

RECONDITIONING

The sparking plug should be dismantled as outlined on p. 435. When a large number of sparking plugs of the same type are to be reconditioned the component parts may be pooled. Defective parts, of course, should

be discarded. The following operations on the component parts should then be carried out :—

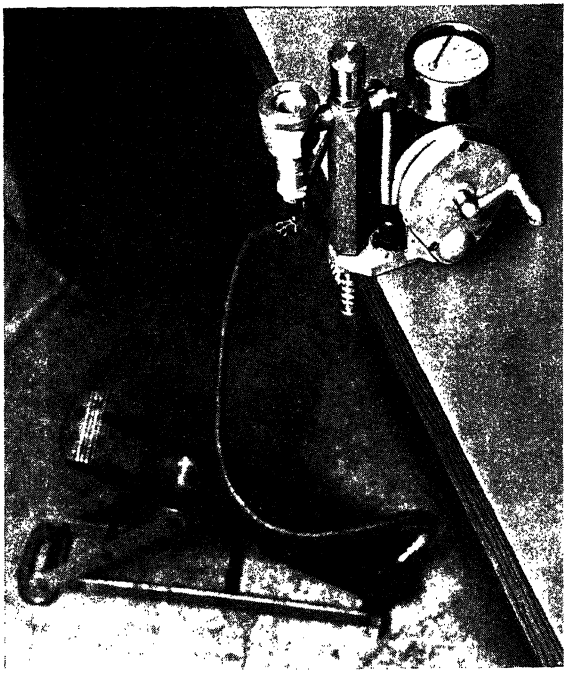


Fig. 5.—SINGLE PLUG TESTER (K.L.G.).

Central Electrode

The central electrode should be set up in the chuck of a lathe and the mica cleaned with a rag dipped in petrol. If a hard deposit of carbon is present a special brush should be used; the mica should then be polished with a soft cloth or mop. If there is any damage to the mica insulation the electrode should be discarded.

The sparking plug tip should then be cleaned with a fine file or emery cloth, the smallest amount of material being removed from the tip. This should be done while the electrode is revolving in the lathe. The threaded part of the electrode and the nut and washer at the top should now be cleaned. If the sparking plug is of the ball-end type, this should be cleaned with very fine emery cloth.

Gland Nut

The sides of the hexagon should be filed if necessary, only a very small amount of material being removed. The threads should then be cleaned with a die nut, after which the gland nut should be washed in petrol.

Body

The body should be set up in a lathe and the thread cleaned with an appropriate die nut. The sides of the hexagon should be filed if necessary, only a very small amount of material being removed. Wash the body in a hot caustic soda solution, of not more than $\frac{1}{2}$ lb. of caustic soda to 1 gallon of water. If carbon is still present, the interior of the body

should be sand blasted at a pressure of not more than 10 lb. per square inch, fine sand being used. It should now be scoured in a petrol bath.

General Information

(*a*) All material used for cleaning and polishing the mica centres must be free from particles of grit or metal. It is advisable to keep cleaning material solely for this special purpose.

(*b*) Mica insulation should on no account be filed or machined to remove any surface defects. Such operations would reduce the diameter of the mica washers and would probably move them, causing a breakdown of the insulation.

(*c*) Central electrodes in which the nickel tip is loose must be discarded; no attempt should be made to recondition them. This type of defect indicates that the sparking plug has been overheated.

(*d*) If the insulation of the central electrode shows signs of being scorched or the surface has deteriorated, the central electrode should be rejected. This defect takes the form of discoloured patches on the mica and indicates that the sparking plug has been blowing. If a sparking plug with this defect is used pre-ignition in the cylinder is possible, due to an excessive temperature being set up by the leakage of hot gases through the mica.

(*e*) The small nut at the top of the central electrode which grips the mica washers must not be tightened, as this may cause the mica wrapping inside the sparking plug to turn and so ruin the insulation.

(*f*) If the central electrode shows excessive reduction in diameter due to the scaling of the steel or due to continual reconditioning, it should be discarded.

(*g*) The mica insulation of reconditioned sparking plugs should, as a general rule, take a high polish, be of a uniform shade of colour and free from defects.

(*h*) The gap between the sparking plug points must not be adjusted by bending the central electrode under any circumstances; the earth electrode should be bent for this purpose.

(*i*) If the earth electrode in the body is loose, the body must be rejected.

(*j*) The central electrode of some types of sparking plugs has an eccentric tip, and all adjustments for gap must be made by rotating this electrode.

Assembly and Test

This should be carried out as described on pp. 436 and 437.

FITTING AND MAINTENANCE OF REID TURN INDICATORS

By Wing-Commander G. W. Williamson, O.B.E., M.C., M.Inst.C.E., M.I.Mech.E., M.I.E.E.

Fitting of Two-needle Turn Indicator to Blind Flying Panel

ALL Reid Turn Indicators function perfectly in flight without the need for a sprung dashboard, such as is required by some gyroscopic instruments. The Royal Air Force, however, are now providing in military aeroplanes a panel on which the whole of the blind flying instruments are mounted; this panel has an anti-vibration mounting. When mounted, the panel must necessarily have the same lateral and fore and aft horizontal datum for all the gyroscopic instruments; in common with the other instruments the Turn Indicator has merely to be fitted in the existing opening and fixing holes. It will be the duty of an installation mechanic to see that the whole of the blind flying panel is installed in such a way that the three gyro instruments indicate zero when the aeroplane is in dead level flying position, both fore and aft and laterally.

Fitting of Turn Indicators to Standard Dashboard

When a Turn Indicator is fitted to an existing dashboard (without a blind flying panel) the procedure is slightly more complex. With every instrument an instruction book is issued, at the back of which will be found a template to which the hole in the dashboard is to be cut. The instrument is then inserted in the hole which has been specially shaped to take it; and with the aeroplane dead level as regards lateral flying position, screw holes can be marked, and the screws turned home.

Before the screws are positioned, it is essential to note that the bank needle of the two-needle Turn Indicator is exactly at zero; in the Gyorizon, the liquid horizon must be exactly level as regards the two datum points at either side of the dial; in the commercial model of Turn Indicator, the steel ball must rest exactly between the two upright marks etched on the glass.

Fitting the Sensitivity Control

The Gyorizon and the commercial model Turn Indicator are usually supplied complete with a sensitivity control, illustrated and described on page 231 of Vol. I. This should be fitted to the dashboard close to the instrument it is intended to control. A hole $1\frac{1}{4}$ in. in diameter takes the body of the sensitivity control; the flange is then attached to the dashboard by two screws.

Fitting of Venturi

The venturi should next be fitted, care being taken that the small end points into the wind, as illustrated on page 237 of Vol. I. Care must be also taken to choose the most suitable position on the aeroplane, clear of any calm patch; and since the air passes into the venturi at one end and out at the other, it is equally important that there should be no struts or other obstructions in the same fore and aft line either in front of or behind the venturi tube. It is an advantage for the venturi to be fitted as near the dashboard as possible, as the length of piping connecting it to the instrument will thereby be reduced with a consequent saving in suction head; but this consideration should not lead to a sacrifice of air speed, such as might result by the venturi being placed in a position out of the strongest flow of the slipstream.

The other consideration affecting the position of the venturi is that of warmth, to prevent icing up at altitude. Although electrically heated venturi tubes can be supplied if necessary, for ordinary civilian aeroplanes their functioning in any weather and at any probable altitude will be quite satisfactory if the tube is placed in whatever part of the slipstream is carrying a current of warm air. The tube might be mounted, for example, close to the exhaust pipe if the engine is air cooled; and there would be no objection—provided the slipstream is sufficient—to the venturi tube being mounted on the pipe itself when this is a long one running down the side of the fuselage. With liquid-cooled engines, the venturi could be fitted behind the radiator, the air flow being but little interrupted by the cellular formation. On high speed aeroplanes with air-cooled engines, it has been found there is frequently sufficient airflow even behind one of the cylinder heads and 2–3 ft. from it.

Unless the position and siting of the venturi tube has previously been proved satisfactory on another aeroplane of exactly the same type, it is as well to measure in flight the suction head obtained from the venturi before connection is made to the instrument. The piping from the venturi is connected to one end of a U-tube, the other being open to the atmosphere. This mercury U-tube or manometer is illustrated in Fig. 1 of the article on the testing and inspection of Turn Indicators, page 320 of this Volume. In straight flight, with no acceleration on the mercury column, the suction of the venturi should result in there being a difference of 3 in. of mercury between the readings in either leg.

Connection of Piping

Piping is supplied with the instruments, and if the suction obtained for the venturi is proved to be satisfactory, the installation mechanic may then proceed to the connecting up of the instrument. The two-needle Turn Indicator is connected straight to the suction nipple of the venturi by means of a length of pitot tubing and of metal connections similar to those used for air speed indicators; pressure rubber tubing

may be used instead if desired, and if the connections are difficult at the back of the dashboard, a length of pressure rubber tubing may be used in conjunction with all metal piping, care being taken to wire carefully each end of the rubber connector. It is essential to notice that at no point of either the metal or rubber piping is there so sharp a bend as to diminish the suction head, and it is equally important that at no point on the run of this piping should there be any flattening of either tube. To avoid this, there should be no bend more acute than a right angle if possible.

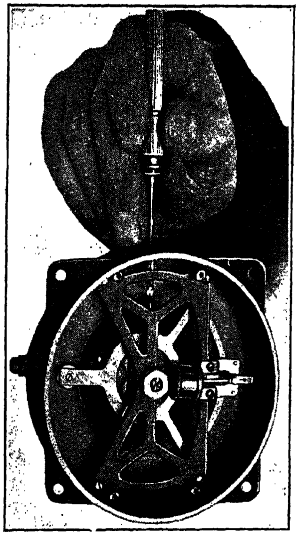


Fig. 1.—SHOWING HOW SCREW-DRIVER MAY BE INSERTED BY THE REMOVAL OF THE ACCESS SCREW.

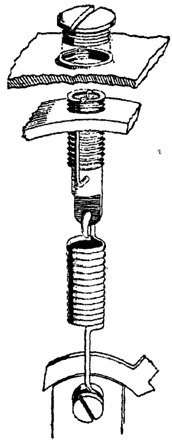


Fig. 2.—ENLARGED VIEW OF ACCESS SCREW, SENSITIVITY SCREW AND SPRING.

Where instruments are supplied with a sensitivity control, this is placed in the pipe line between the instrument and the venturi. The venturi is connected to the vertical tube of the sensitivity control and the instrument to the horizontal outlet; pitot tubing or rubber tubing may be used in either case, care being taken, as previously stated, to wire the connection at each end. All preliminary tests of the instrument should be made with the sensitivity control at ON.

Adjustment by Sensitivity Control

Before making any adjustment to the sensitivity, the aeroplane should now be flown, the sensitivity control being fully open as detailed in a previous paragraph. In most cases it will be found that little or no alteration is required, since the sensitivity is very carefully adjusted before the instrument leaves the works. In high speed aeroplanes in which a sensitivity control is being used, however, it is possible to reduce the sensitivity by turning the control knob towards the off position, until the sensitivity itself is suited to that particular aeroplane or to the requirements of the pilot. It must be remembered that the gyro will require five minutes to slow down to the new sensitivity.

Adjustment by Sensitivity Screw—Two-needle Turn Indicator

If it becomes necessary to adjust the sensitivity of the two-needle

Turn Indicator, this may be carried out by a very slight turn of the sensitivity spring inside the case. Fig. 1 shows that a screwdriver may be inserted by the removal of the access screw; and Fig. 2 gives an enlarged view of the access screw, the sensitivity screw and the spring.

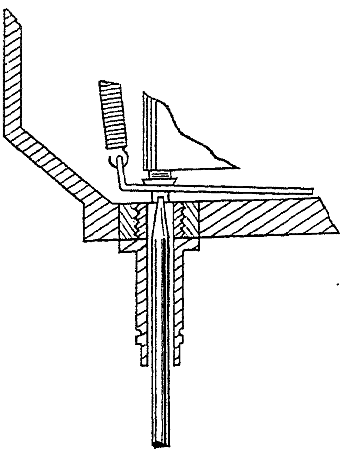


Fig. 3.—SENSITIVITY ADJUSTMENT ON GYORIZON.

outlet at the bottom of the case.

A slight turn anti-clockwise will give reduced sensitivity and a slight turn clockwise will give increased sensitivity; the altered sensitivity will be above or below that with which the instrument has been sent out; rates of turn for Mark I and Mark IA two-needle Turn Indicators are given on page 222 of Vol. I.

Sensitivity Adjustment — Gyorizon and Commercial Model

The sensitivity spring and its effect upon the gyro is clearly shown in Fig. 2 of the article on the Gyorizon, page 227 of Vol. I. In this instrument there is no access screw; the adjustment of the sensitivity spring is carried out by the insertion of a small screwdriver into the air outlet at the bottom of the case. This is illustrated in Fig. 3; one complete turn clockwise is usually sufficient to give the increased sensitivity required; on the Gyorizon or commercial model sensitivity can be reduced either by the sensitivity control or by not more than one turn of this screw anti-clockwise. If there is difficulty in carrying out this adjustment through the air outlet, the nipple may be removed with a spanner, but this procedure is not recommended as frequent removal might result in an air leak there. Rates of turn for the Gyorizon and commercial model are on page 235 of Vol. I.

Maintenance of Turn Indicators

These instruments have been specially designed so as to require a minimum of care and maintenance. The duralumin parts have been anodically treated and only rustless steel is used for the gear pinions and pivots. Brass parts are electrically tinned and lacquered; the case is anodically treated before being stove enamelled; any screws or other small parts not of rustless steel are cadmium plated.

A brief examination of the venturi and instrument every 200 or 300 hours is therefore all that should be required. The inside of the venturi tube should be cleaned out carefully to remove dust or oil which may

have blown back from the engine and the neck of the tube cleared of any dust which might be blocking the circular slot.

The only maintenance necessary in regard to the Turn Indicator itself is an occasional examination to see that the air connection is air-tight and that the bezel of the case is screwed home so that no air leaks can occur. An occasional cleaning of the dust cap is also necessary; the three small screws in the top cap of the inlet nozzle should be removed, the double gauze filters taken out, cleaned and replaced.

On these Turn Indicators, no maintenance of the inside mechanism is required; all the time the instrument is running it is automatically cleaning itself, the inlet and outlet jets providing a scavenging arrangement on the same principle as vacuum cleaning.

The examination of the Gyorizon is slightly different from the above procedure; this instrument can be removed from its case quite easily, the case cleaned out and the movement replaced. The bezel ring is unscrewed and the glass removed. The cover is then taken off the dust cap at the bottom of the case; it is held in position by six small screws. Beneath the gauze filter will be found a screw which combines the air inlet and the retaining screw for the instrument. A screwdriver, or alternatively a coin such as a penny, can be inserted in the head of this screw in order to remove it; when it is removed the whole unit will slide out of the case and can be thoroughly inspected.

Thousands of these Turn Indicators are in use by the Royal Air Force, and require no more maintenance than that detailed above; instruments are returned for complete overhaul on the average about once every five years.

THE "BRISTOL" MERCURY ENGINE

SERIES VII, VIII AND IX

RUNNING AND MAINTENANCE

By Edmund G. Holt

THE Mercury VII, VIII and IX engines are of the well-known "Bristol" nine-cylinder radial type and incorporate a high ratio supercharger. Basically, the engines are identical, and differ only in respect of the reduction gear ratio.

In this section we are concerned mainly with operation, maintenance and running adjustments as affecting the ground engineer; although notes are also included on the manipulation of throttle, mixture, etc., controls during take-off, climb and in flight.

Before Starting

Engine in Regular Use

When the engine concerned is in constant and regular use, the following general inspection procedure should be carried out :—

1. Ensure that sufficient fuel of the correct grade is in the tank. These engines are designed to operate on fuel to Air Ministry Specification D.T.D.230 (87 octane).

2. Ensure that the oil tank contains an adequate supply of lubricating oil of an approved brand. Give a minimum oil allowance of 12 pints for each hour's fuel supply carried, and do not run the engine with less than 2 gallons in the tank.

3. Remove and clean the bottom sparking plugs in cylinders Nos. 4, 5, 6 and 7. This is important, as, owing to the inclination of these lower cylinders, any condensation or oil present tends to drain on to the sparking plugs.

4. See that the main oil cock, if fitted, is locked in the open position. On the majority of modern installations, however, the oil cock is not fitted; a spring-loaded check valve is included in the engine oil pump which prevents flooding of the engine whilst standing idle.

5. See that all cowling panels are secure, and that no tools or cleaning rags, etc., have been left on the engine or mounting.

6. If the engine has been standing for longer than forty-eight hours in an air temperature of about 5° C. or overnight in air temperatures of 0° C. and below, it is necessary to prime the blower bearings and the lubrication system with oil as follows :—

Blower Bearings (see Fig. 1.)—(*a*) Inject two pumps full of warm

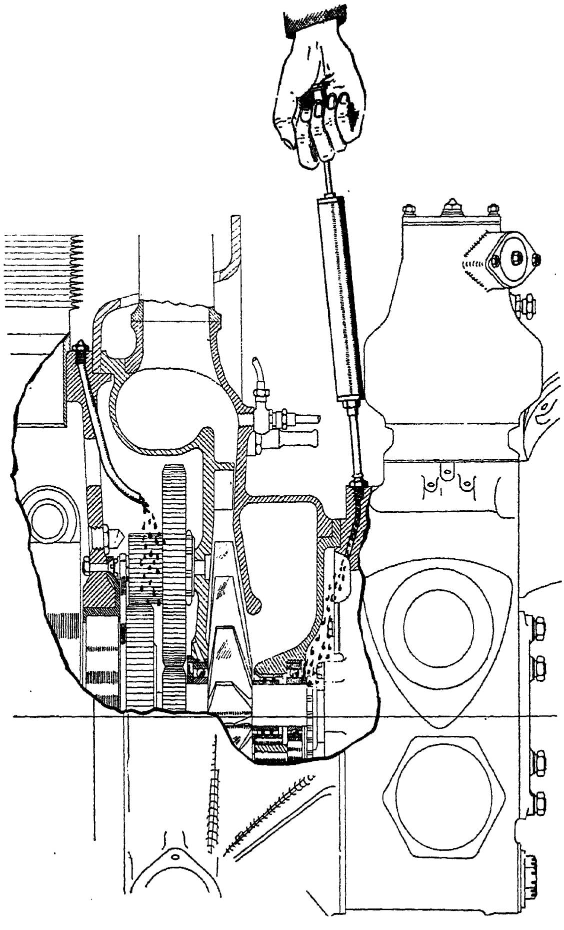


Fig. 1.—OIL PRIMING OF BLOWER BEARINGS AND GEARS.

engine oil through the priming nipple on the engine rear cover, using the oil gun provided.

(*b*) Inject two pumps full of warm engine oil through the nipple on the crankcase.

(*c*) Turn the crankshaft through three or four revolutions immediately afterwards to distribute the oil.

Lubrication System (see Fig. 2).—

(*a*) Inject half a gallon of hot engine oil (50° C.) through the pressure gauge connection on the rear cover.

(*b*) Use a pressure of between 10 and 60 lbs. per square inch. In no circumstances use cold oil or a pressure less than 10 lbs. per square inch as there would then be a danger that the oil would not reach the more remote bearings.

(*c*) If the engine is fitted with a variable pitch airscrew control valve ensure that it is closed, *i.e.*, in the coarse pitch position, during the priming operation, so as to prevent oil escaping into the variable pitch oil circuit.

(*d*) Refit the pressure gauge connection and lock.

If atmospheric temperature conditions have been such as to necessitate the foregoing oil priming, the lapse of time between priming and running

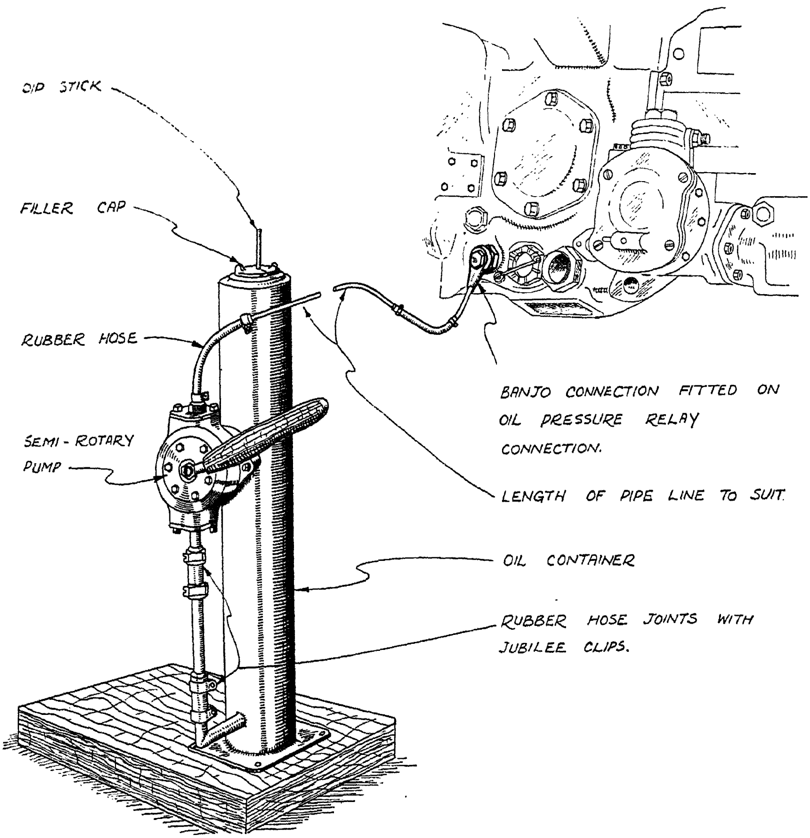


Fig. 2.—OIL PRIMING OF ENGINE LUBRICATION SYSTEM.

Showing a typical apparatus for pumping oil through rear cover pressure gauge connection.

the engine should not exceed four hours, otherwise the priming operation will be rendered ineffective.

As the oil used for priming will subsequently come into circulation, it is of the utmost importance to ensure that the pump employed for priming the engine, also the oil gun for priming the blower bearings, is thoroughly washed with petrol before use and that only clean filtered engine oil of an approved brand is used.

Newly Installed Engine or after a Long Stand By

In the case of an engine that has been overhauled, newly installed or out of use for a lengthy period, the following more detailed examination, in addition to those items already specified in the preceding paragraphs, is necessary before starting up for the first time :—

1. Check the tightness of all main external nuts, bolts, etc., on the engine and mounting, and see that they are securely locked.

2. Operate all engine and magneto controls to see that they work freely and ensure that the full range of movement is available on the throttle, etc. Note that all control mechanism pins are securely split pinned.

3. Remove all the sparking plugs, rotate the engine and watch for signs of oil flooding in the lower cylinders. If signs are observed continue to turn the engine until all surplus oil is drained out.

4. Clean all the sparking plugs and see that the gaps are correctly set to 0·012 in.–0·015 in. Where facilities are available test the plugs under pressure on a testing rig.

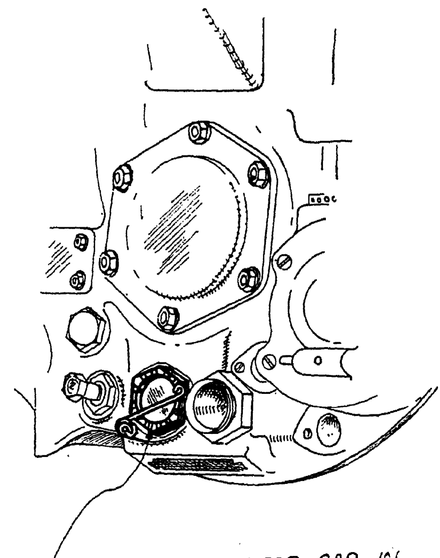


Fig. 3.—AFTER REPLACEMENT OF REAR COVER OIL FILTER ENSURE THAT THE CAP IS SECURELY LOCKED BY THE LOCKING SPRING.

5. Check the clearances on all valves and where necessary reset (see p. 466).

6. Replace the sparking plugs after smearing the threads lightly with a mixture of graphite and grease. Fit new washers of the rolled copper type.

7. Inspect the fuel pipes and system. Drain the tanks and flush out with clean petrol; clean the filters, replace and lock. Ensure that all unions are safely locked and fill the tanks with approved fuel, which must be clean and free from water.

8. Inspect all pipe joints in the oil system, see that the clips are secure and that the rubber hose connections are neither damaged nor perished. Withdraw the rear cover oil-filter and thoroughly clean with a stiff brush and paraffin. After replacement ensure that the filter cap is securely locked (see Fig. 3).

9. Drain the oil tanks and flush out with paraffin or petrol. If, however, paraffin is used the tanks should afterwards be flushed out with petrol, finally making sure that all the petrol is drained away.

10. Replenish the tanks, giving at least the specified minimum oil allowance (see p. 446).

11. If an oil shut-off cock is fitted see that it is locked in the fully open position.

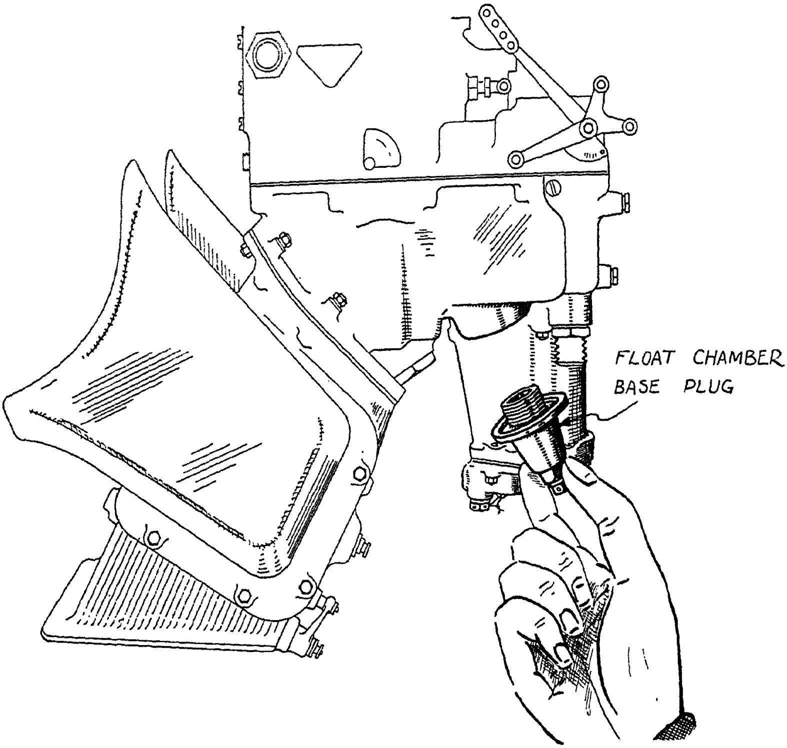


Fig. 4.—BEFORE STARTING ENGINE AFTER STORAGE UNSCREW BOTH FLOAT CHAMBER BASE PLUGS AND FLUSH CHAMBERS WITH PETROL TO REMOVE PROTECTIVE OIL.

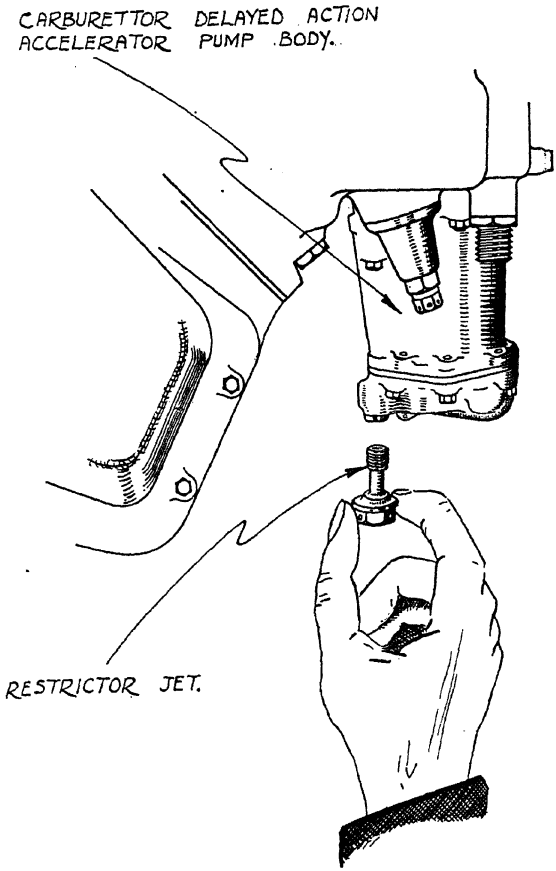
12. If the engine is fitted with a variable-pitch airscrew, inspect the oil supply pipes and see that the joints are satisfactory.

13. Charge the valve-rocker bearings with approved grease, through the right-angled nipple on the rear of each rocker bracket, using the grease gun provided. Continue to inject grease until it just oozes from around the bearings; wipe away the surplus. Also grease the rocker adjusting screws by means of the appropriate gun. (See also note *re* felt lubricating pads on p. 477.)

14. Inspect the magneto contact breakers, check the rocker arms for freedom and see that the points are set to the correct gap (0·011 in. to 0·013 in.) and are not pitted.

15. Remove the magneto distributors, ensure that they are scrupulously clean and that the spring-loaded starter-brush is making good contact on the centre of the distributor rotor.

16. Remove the carburetter float chamber drain-plugs and thoroughly flush out the float chambers with clean petrol to remove all traces of



5.—BEFORE STARTING ENGINE AFTER STORAGE REMOVE AND CLEAN ACCELERATOR PUMP RESTRICTOR JET.

protective oil which may have been injected into the carburetter to prevent corrosion during storage (see Fig. 4). Also remove and clean the restrictor jet in the accelerator pump-cover (see Fig. 5).

17. If the engine is fitted with a single-type fuel pump, grease the spindle through the nipple provided, using Stanavo No. 2 grease.

18. On either the single or the dual fuel pump, whichever happens to be fitted, remove the priming plug and prime the fuel system with the standard grade of approved fuel. Replace, securely tighten and lock the plug on completion of this operation.

19. If the engine has been standing for five days or longer, in moderate atmospheric temperature conditions, prime the blower bearings and lubrication system with oil as described in para. 6, p. 446.

20. Check the track of the airscrew blades and ensure that the airscrew is tight on its hub, and that the hub is tight on the airscrew shaft. When checking the tightness of the ten bolt nuts, diametrically opposite nuts must be tightened alternately and progressively, and locked with new split pins. Finally ensure that the locking devices of the airscrew shaft nut are in position and secure. To check the track of the blades the aeroplane should be set with its datum line level and, if possible, the load taken off the undercarriage by jacking up the fuselage; chocks should be placed at the front and at the rear of each

wheel. With one sparking plug removed from each cylinder to facilitate turning the engine, position the airscrew so that one blade is vertical and below the engine centre line. Behind the airscrew place a rigid box or trestle and on it fix a pointer in such a position that it just touches the trailing edge of the blade at approximately $\frac{3}{4}$ blade radius. Turn the airscrew so that the next blade passes the pointer and measure the difference. Rotate the airscrew by holding near the hub and not at the blade tip, and take care not to disturb or rock the aeroplane. The maximum variation in blade track should not exceed 0·100 in. when measured at not less than 5 ft. radius. As an additional precaution the tracking tests should be repeated on the front sides of the airscrew on the highest camber.

21. If a De Havilland Hamilton variable-pitch airscrew is fitted it should be checked for tightness on the airscrew shaft in the following manner. Remove the locking ring and unscrew the cylinder head, using the spanner provided. Disengage the piston locking ring by removing the split pins and using the same spanner check the tightness of the piston. The applied tightening moment should be in the region of 800 ft. lbs., or in other words, it is satisfactory to apply a force of from 250 to 300 lbs. at the end of a 3 ft. bar. To ensure that the hub is pulled home, the bar should be given one smart blow on the section closest to the hub using a hammer weighing not more than $2\frac{1}{2}$ lbs. and with a normal swing, the weight meanwhile being suspended on the end of the bar. Do not attempt to tighten the piston by hammering on the end of the bar. After tightening secure the piston with the lock ring and fit new $\frac{3}{32}$-in. split pins, two or three as required, to prevent movement. Fit the cylinder head gasket, taking care that it rests squarely on the cylinder head; the gasket should be held in position with a thin coating of approved grease. Replace the cylinder head, tighten with the spanner and finally secure it with the locking ring.

Starting Procedure

Always ensure that the aeroplane anchorages, chocks or moorings in the case of flying boats or seaplanes, are in position and secure.

Types of Starters

One or the other of the undermentioned types of starter unit will be fitted and the procedure for the use of each is laid down under relevant headings below.

1. Combined hand or electrically operated direct turning-gear unit. Rotax Type E.160.
2. Hand-operated inertia starter unit. Rotax Type XI.
3. Combined hand or electrically operated inertia starter unit. Rotax Type XI.

1. Starting with Hand or Electric Turning Gear

Hand Turning Gear.—(*a*) See that starter magneto and main magneto switches are in the "OFF" position.

(*b*) Set the fuel cocks in the "ON" position and also turn on the fuel cock to the priming system.

(*c*) Place the starter handle in position.

(*d*) Set the mixture control in the normal position, open the throttle fully and bring back along the quadrant until very nearly closed.

(*e*) If a V.P. airscrew is fitted, set the control in the fine pitch (take-off) position.

(*f*) Set the air intake heat control to the position for admitting cold air.

(*g*) If the installation concerned is provided with controllable cowling gills, these should be set in the fully open position.

(*h*) Place the starter and main magneto switches in the "ON" position.

(*j*) Operate the primer pump until the suction pipe and pump are primed with fuel as indicated by the "feel" of the plunger.

(*k*) Rotate the engine by means of the turning gear, and at the same time operate the primer pump to inject approximately six to eight pumps full of fuel into the priming system.

Note.—It is impossible to lay down hard and fast rules for engine priming and the quantity of fuel injected will require to be varied as experience dictates to suit the particular climatic conditions obtaining. The amount of priming quoted throughout the starting procedure is the average for normal climatic conditions, and may need to be increased in very cold weather or *vice versâ* in hot weather. When starting a hot engine take care not to over prime, one or two pumps full should be sufficient.

(*l*) Continue turning the engine and at the same time crank the hand starter magneto vigorously until the engine starts. On certain installations the starter magneto may be interconnected with the turning gear or inertia starter, in which case it will not, of course, be turned by hand. With this arrangement do not switch on the starter magneto until the engine has completed approximately two revolutions.

(*m*) As soon as the engine is running, switch off the starter magneto, turn off the priming cock and set the air intake heat control to the position for admitting warm air.

(*n*) Should the engine fail to start, make further attempts before injecting more fuel.

Electric Turning Gear.—(*a*) Prepare the engine as detailed in para. 1, sub-para. (*a*) to (*h*) above.

(*b*) Prime the engine with fuel as detailed in para. 1, sub-para. (*k*), but do not turn the engine.

(*c*) Press the starter motor switch and keep in the "ON" position,

at the same time vigorously turning the starter magneto, unless it is interconnected with the starter unit as previously mentioned. After approximately three to four seconds the engine should start, but should it fail to start in eight to ten seconds, release the switch and investigate the cause. In no circumstances should the starter motor be run for longer than ten seconds; if it should be run for this maximum permissible time, allow it to cool off for at least thirty seconds before making a further attempt at starting.

(*d*) As soon as the engine has started, switch off the starter magneto, turn off the priming cock and set the air intake heat control to the warm air position.

2. Hand-operated Inertia Starter

(*a*) Prepare the engine as previously detailed and inject approximately six to eight pumps full of fuel into the induction system by means of the priming pump.

(*b*) Place the crank handle in position and ensure that the operating rod is in the correct position, *i.e.*, starter jaws disengaged.

(*c*) Turn the starter crank slowly at first without applying any great effort and as the speed increases exert a greater force. Continue rotating the handle until it attains a speed of 75 to 80 r.p.m., which should take approximately 30 to 45 seconds.

(*d*) Immediately the requisite speed of the starter handle has been attained, turn the hand starter magneto vigorously and pull the operating rod to engage the starter jaw with the engine jaw and hold in engagement until the engine fires.

Note.—In order to minimise delay, it is important, in the case of a hand-operated starter magneto, that the magneto is being turned when the starter jaw engages, as the engine only rotates one and half to three revolutions.

(*e*) As soon as the engine is running, switch off the starter magneto, turn off the priming cock and set the air intake control to the warm air position.

(*f*) If the engine fails to start, push on the operating lever to ensure disengagement of the starter jaws before repeating the foregoing procedure.

Important Note.—The engine will not start unless the requisite speed has been attained on the cranking handle, as the necessary energy will not be available in the fly-wheel. As experience is gained, the operator will learn to tell from the note of the fly-wheel when he has obtained the correct speed before operating the clutch throw-in lever. The starter jaws disengage automatically as soon as the engine starts, but care must be taken to ensure that free movement of the operating rod is not restricted when returning to the disengaged position.

3. Combined Hand or Electrically Operated Inertia Starter

With this unit the energy is imparted to the fly-wheel either by hand cranking or by an electric motor. When the hand cranking method is employed the procedure is identical to that described in para. 2 above.

Electrically Energised Inertia Starter.—(*a*) Prepare and prime the engine as previously described.

(*b*) Push the switch to start the motor and keep it in the "ON" position for five to six seconds. This period will normally be sufficient for the fly-wheel to attain its correct speed.

(*c*) As soon as the required speed is reached pull the switch control, which will open the electrical circuit and at the same time engage the starter jaw with the jaw on the engine crankshaft.

(*d*) At the same time as the clutch is engaged, turn the starter magneto vigorously.

(*e*) Immediately the engine starts, place the starter magneto switch in the "OFF" position, turn off the priming cock and set the air intake control to the warm air position.

Note.—The starter motor must not be operated for periods longer than ten seconds, and should the engine fail to start within this time, allow the motor to cool down for at least thirty seconds before making a further attempt.

After Starting

The high initial oil pressure device incorporated in the oil pump of these engines provides a safeguard against oil starvation during the first few minutes of running.

Although with this device in action it is possible to accelerate almost immediately after starting—provided the minimum permissible oil inlet temperature of 5° C. has been reached—it is strongly recommended that, under normal conditions of operation, the engine should not be opened up to full power or the aeroplane taken off until the oil inlet temperature is at least 15° C.

In the case of an engine that has been started up for the first time after installation or a long stand by, it is imperative that the full warming-up procedure and ground test be carried out as stipulated below.

Warming up

1. Immediately after starting, the engine should be throttled to approximately 600 r.p.m. and allowed to run at this speed for about five minutes. The oil pressure should build up straight away; should it fail to do so, discontinue the run and investigate the cause.

2. Open up from 600 r.p.m., in steps of 200 r.p.m. every two minutes, keeping the speed below 1,000 r.p.m. until the oil pressure settles and the oil inlet temperature rises to at least 15° C. It should be noted that while the high initial oil pressure device is in operation, the oil pressure

will vary with the temperature and engine speed, and may rise to 150-200 lbs. per square inch when starting with cold oil. As the oil temperature rises, however, and the H.I.O.P. device goes out of action, the pressure will settle at the normal 80 lbs. per square inch. If, after settling, the pressure commences to fluctuate or is more than 5 lbs. per square inch below normal at 1,200 r.p.m. or over, the oil system should be carefully examined for leaks, which, if found, should be rectified.

The oil relief valve is adjusted and sealed by the manufacturers and must only be re-adjusted by authorised persons. In the unlikely event of alterations to the setting being necessary, it is important that the oil temperature be raised to 70° C. before finally sealing the adjustment.

3. When satisfied that all is functioning normally, set the air intake control to the cold air position after which the engine may be opened up to check r.p.m., boost, etc., as detailed below.

Ground Test

1. It is important to note that the engine should not be run at full throttle for periods exceeding ten seconds, as in the majority of installations it is heavily cowled and does not receive its normal cooling air-stream until in flight.

2. Always open and close the throttle in a smooth progressive manner and without snatching. This is particularly important with a geared engine turning a heavy airscrew owing to the high inertia of the airscrew.

3. On installations fitted with controllable cowling gills, it is essential that these be opened fully during all ground running.

4. *Checking Boost and R.P.M.*—With a variable-pitch airscrew set in the fine pitch position and the mixture control at the "normal" setting, a boost pressure of + 3½ lbs. per square inch should be obtained at full throttle.

With the same airscrew pitch setting, move the mixture control back into the "rich" position, when a boost pressure of + 5 lbs. per square inch should be obtained at full throttle.

In the event of any adjustment to the boost pressure being required proceed as described on p. 468.

The minimum speed at which the maximum take-off boost of + 5 lbs. per square inch will be obtained is 2,050 r.p.m., and this figure should be obtainable on the ground with either a fixed pitch airscrew or a variable-pitch airscrew in the fine pitch position.

5. *Checking Magnetos—Drop in R.P.M.*—Set the mixture control to "normal" and gradually open up to full throttle and + 3½ lbs. per square inch boost, then switch off each magneto alternately and note the drop in r.p.m. With either magneto switched off the drop should not exceed 120 r.p.m. Never, in any circumstances, switch off both magnetos when the engine is running at a speed in excess of 800 r.p.m.

6. *Checking Variable-Pitch Airscrew Control.*—To check the function-

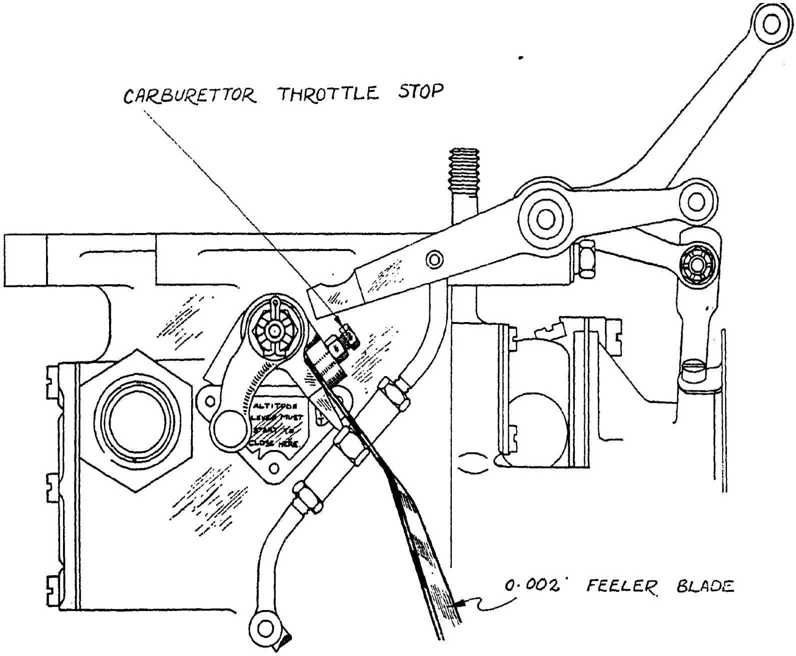


Fig. 6.—BEFORE UNDERTAKING ADJUSTMENT OF SLOW RUNNING STOP, CHECK THAT THROTTLE SPINDLE LEVER IS ACTUALLY IN CONTACT WITH STOP BY MEANS OF 0·002 IN. FEELER GAUGE.

ing of a variable-pitch airscrew control, throttle the engine back to approximately 1,500 r.p.m., with the airscrew in the fine pitch position and at this speed operate the control to change the airscrew setting from fine to coarse pitch. If the pitch-operating mechanism is working correctly, the engine speed will decrease approximately 60–70 r.p.m. for each degree of movement of the blades. On completion of this test return the airscrew blades to the fine pitch position.

7. *Checking Acceleration.*—Allow the engine to idle for a few minutes after which open the throttle steadily (not violently). The engine should accelerate from the slow running or any intermediate throttle setting to the maximum ground r.p.m. without any signs of a "flat spot" or cutting out due to a weak mixture. If the acceleration is unsatisfactory, proceed as detailed on p. 467.

8. *Slow Running.*—The throttle stop on the carburetter is set by the makers when the engine is on the test bed and should not normally require alteration. Owing, however, to possible variations in the characteristics of different airscrews and slight differences in the grade of fuel used, a minor adjustment may sometimes be found desirable. First run the engine until it is thoroughly warmed up, then release the throttle

stop-lock nut and screw the stop slowly in or out, as required, until the desired slow running speed (approximately 500 r.p.m.) has been obtained, after which tighten the lock nut securely. Before undertaking this adjustment it is important to ensure that the throttle spindle lever is actually in contact with the throttle stop and this may be checked by means of a 0·002 in. feeler gauge as shown in Fig. 6.

9. *Vibration.*—There should be no undue vibration throughout the entire speed range of the engine, but should any be experienced the following possible causes should be considered :—

(a) *Airscrew out of Balance.*—Rough running due to this cause may generally be recognised by a characteristic rhythmic beat, increasing in frequency with increasing r.p.m. Check the track of the airscrew blades and ensure that the airscrew is tight on its hub and the hub tight on the shaft. If no improvement, remove the airscrew and check for static balance.

(b) *Unevenly Set Valve Clearances.*—Re-set to the standard clearances (see p. 466).

(c) *Sparking Plugs Dirty or Badly Gapped.*—Clean, re-adjust the gaps and test under pressure on a rig.

(d) *Slackened Bracing or Worn Pins in the Fuselage Structure in the Rear of the Engine Bay.*—The point of occurrence of vibration may be detected by placing a finger on the suspected fitting while the engine is idling, when relative movement between the two surfaces should be readily apparent. Apply the appropriate remedy.

Shutting Down

These engines are provided with carburetter slow running cut-out valves which are controlled from the cockpit. When shutting down, close the throttle, switch off the magnetos and operate the control to pull out the cut-out valves. It is important to follow this sequence of operations as, were the pilot to release the control accidentally, with the magnetos still switched on, the engine would probably pick up again (see Fig. 7). Immediately the engine has stopped the control should be returned to the normal open position.

After Stopping the Engine

After stopping the engine following a first run, examine for fuel or oil leaks and check over all external nuts ; re-tighten if necessary. Remove the oil filter in the sump and examine for signs of foreign matter ; if trace of this be found drain the system and wash out the tanks, repeat running and cleaning operations until the system is clear. In the event of bronze, white metal or other metallic particles being found in the filter the origin should be located before further running is carried out.

Check the airscrew hub or variable-pitch airscrew for tightness on

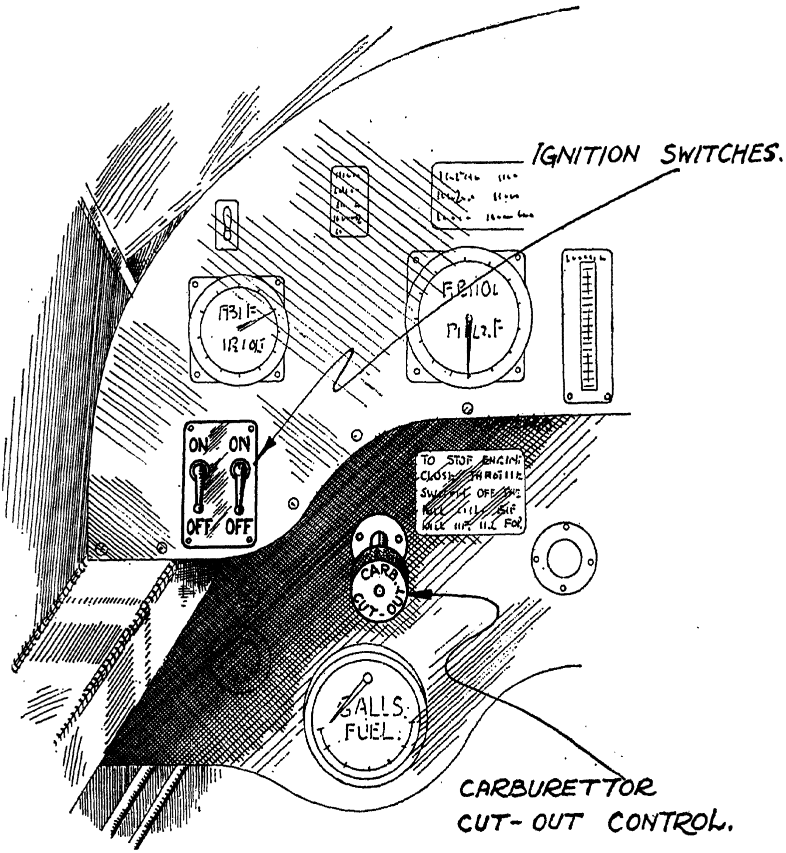


Fig. 7.—WHEN STOPPING THE ENGINE SWITCH OFF THE MAGNETOS BEFORE OPERATING THE CARBURETTOR CUT-OUT VALVE CONTROL.

the shaft as previously described, finally making sure that the airscrew locking devices are in position and secure.

TAKE OFF, CLIMBING AND IN FLIGHT

1. Notes on the Operation of Throttle and Mixture Controls

Take-Off (see Fig. 8).—With the variable-pitch airscrew control in the fine pitch position, first spring the mixture control lever in the cockpit through the quadrant gate to the "rich" position, and then move the throttle to the fully open position when maximum take-off boost should be obtained.

Climb (see Fig. 8).—Whilst climbing with controls in take-off position, maximum boost will gradually fall to rated boost ($+ 3\frac{1}{2}$ lbs. per sq. in.), at

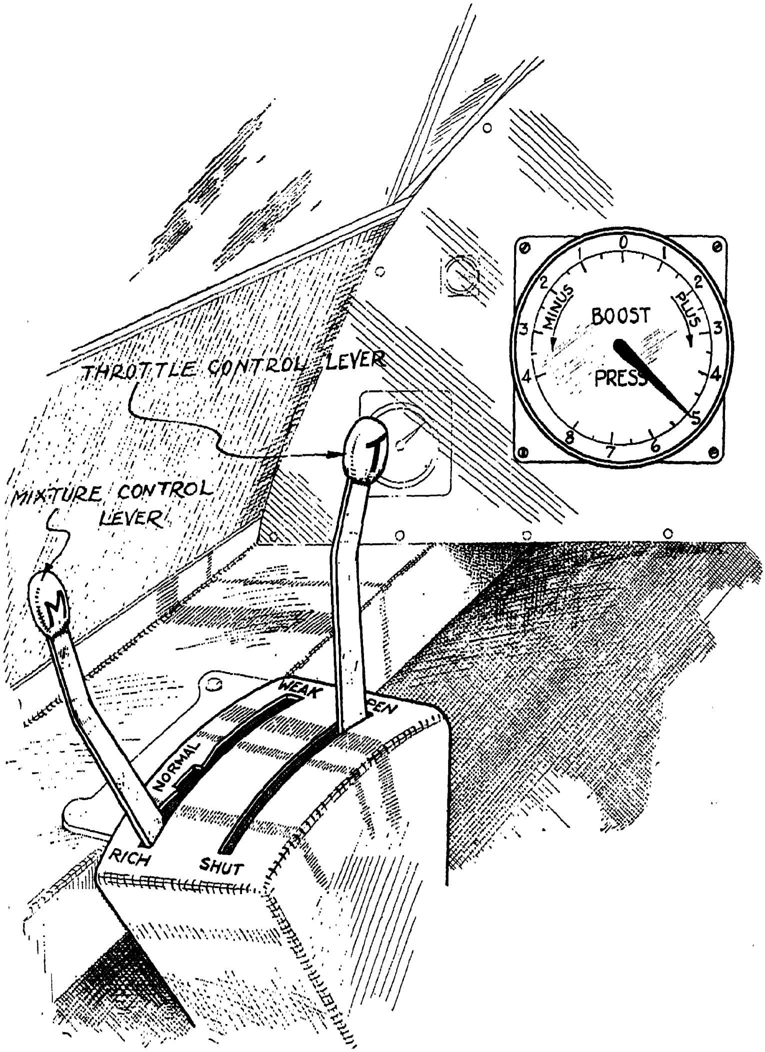


Fig. 8.—SHOWING RELATIVE POSITIONS OF THROTTLE AND MIXTURE CONTROL LEVERS DURING TAKE-OFF AND INITIAL CLIMB.

approximately 13,000 ft. Climbing with the mixture control lever in the fully rich position when above the rated height will, however, result in an increase in fuel consumption with height, as the mixture strength is set excessively rich with the carburetter enriching device in operation. The pilot should therefore move the mixture control lever forward through the gate to the "normal" setting (which disengages the boost

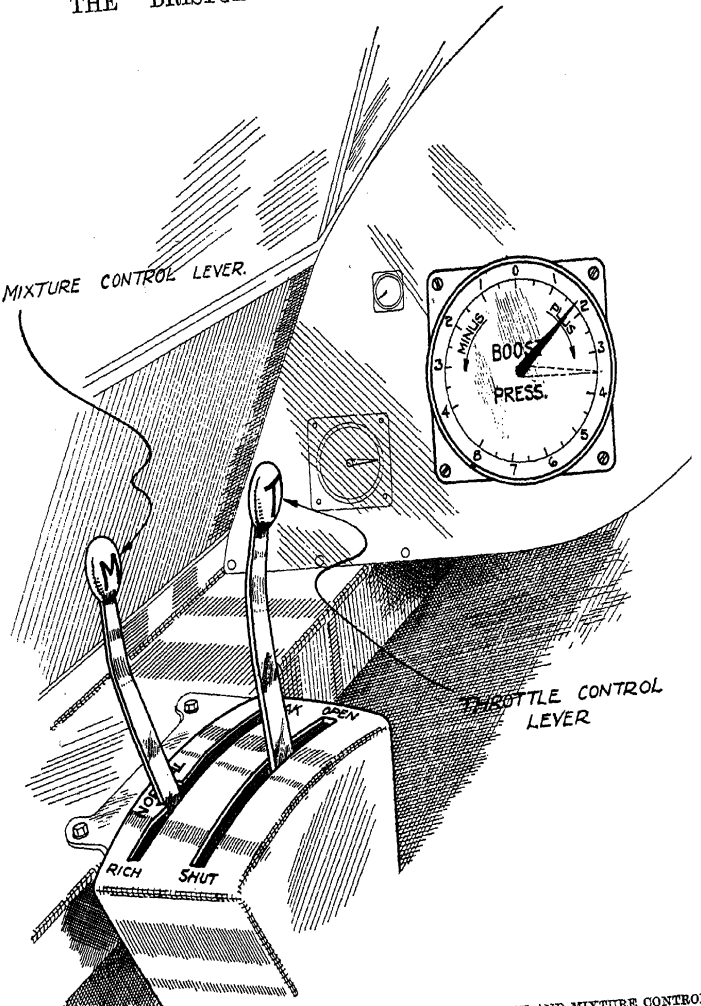


Fig. 9.—SHOWING APPROXIMATE RELATIVE POSITIONS OF THROTTLE AND MIXTURE CONTROL LEVERS WHILE CRUISING AT NORMAL MIXTURE STRENGTH.

over-riding and carburetter enriching device) when the boost pressure begins to fall below + $3\frac{1}{2}$ lbs. per square inch.

In no circumstances must the maximum permissible climbing r.p.m. of 2,650 be exceeded.

Cruising at Normal Mixture Strength (see Fig. 9).—Having reached the required altitude, with the variable-pitch airscrew in the coarse

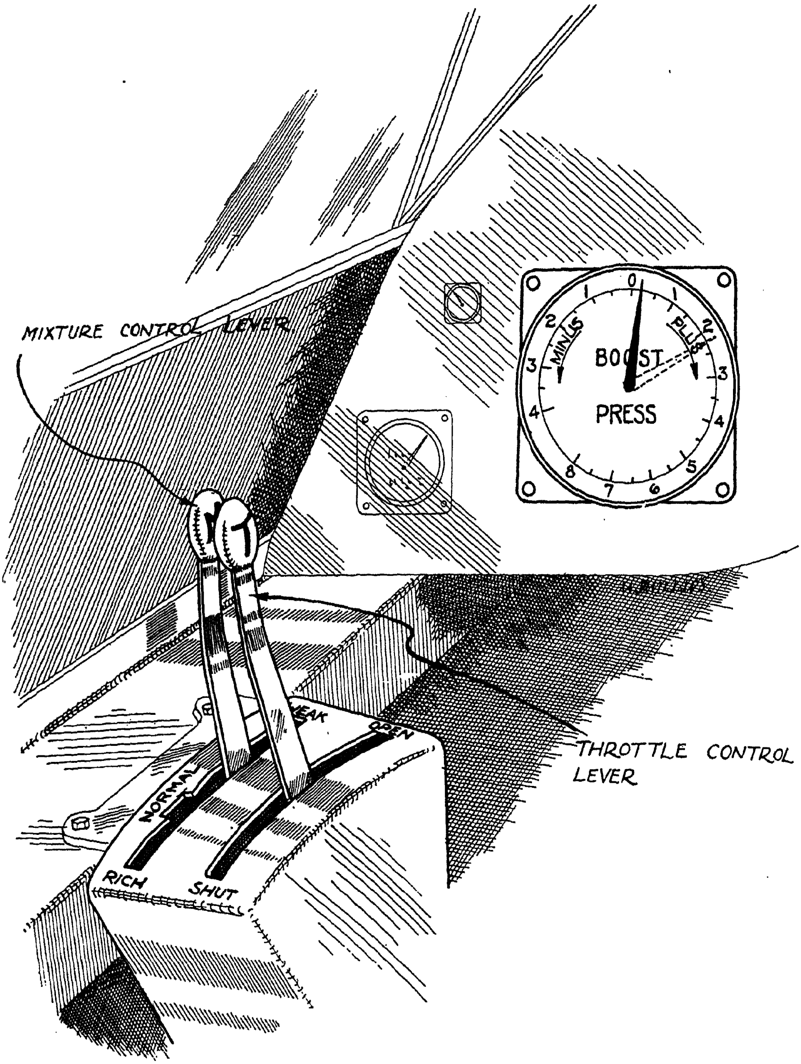


Fig. 10.—SHOWING APPROXIMATE RELATIVE POSITIONS OF THROTTLE AND MIXTURE CONTROL LEVER WHILE CRUISING AT ECONOMY MIXTURE STRENGTH.

pitch position, level out for cruising, close the controllable gill cowling, if fitted, and proceed as follows :—

1. Adjust the throttles to give the desired cruising r.p.m.
2. Advance mixture control gradually towards the "weak" position until the r.p.m. just cease to increase.

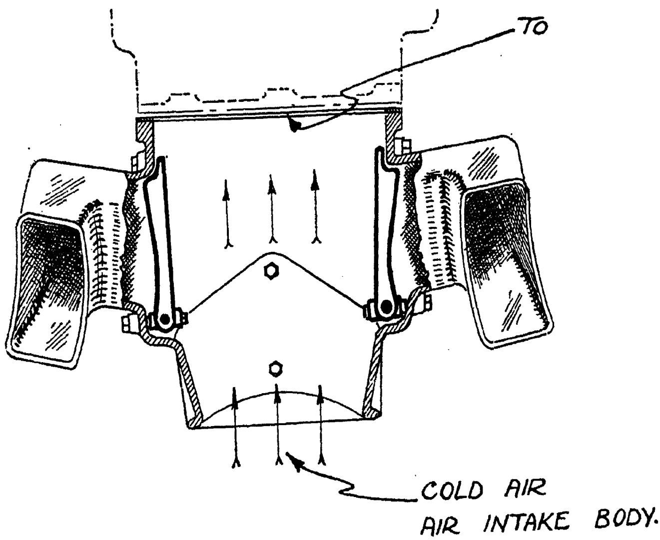


Fig. 11.—SHOWING AIR INTAKE SHUTTERS IN POSITION TO ADMIT COLD AIR.

3. Gradually throttle back to original r.p.m.

Cruising at Economy Setting (see Fig. 10).—When the most economical fuel consumption is required, it is permissible to utilise extra mixture control until a 3 per cent. drop in r.p.m. is obtained. It must be distinctly understood, however, that this weak mixture setting is intended for cruising conditions only and must never be used when operating at a boost pressure greater than + $2\frac{1}{4}$ lbs. per square inch or r.p.m. in excess of 2,400. To obtain the correct setting of the mixture controls the following procedure must be strictly observed :—

1. With the aeroplane flying level at the correct cruising r.p.m. and variable-pitch airscrew in the coarse pitch position, set the mixture control as described above for normal mixture strength.

2. Advance the mixture control further towards the " weak " position until a 3 per cent. drop in r.p.m. is obtained.

3. Gradually open the throttle to regain the original r.p.m.

It is important that the aeroplane be flown in steady and level flight throughout this procedure.

If, during the course of the flight the altitude is changed appreciably, that is, by more than 500 ft., the mixture control must be returned to normal and the foregoing procedure repeated.

2. Use of Air Intake Heat Control

The air intake shutters are controlled from the cockpit, and may be operated to supply to the carburetter either cold air or air that has been heated by passing over the heads of Nos. 5 and 6 cylinders. For starting

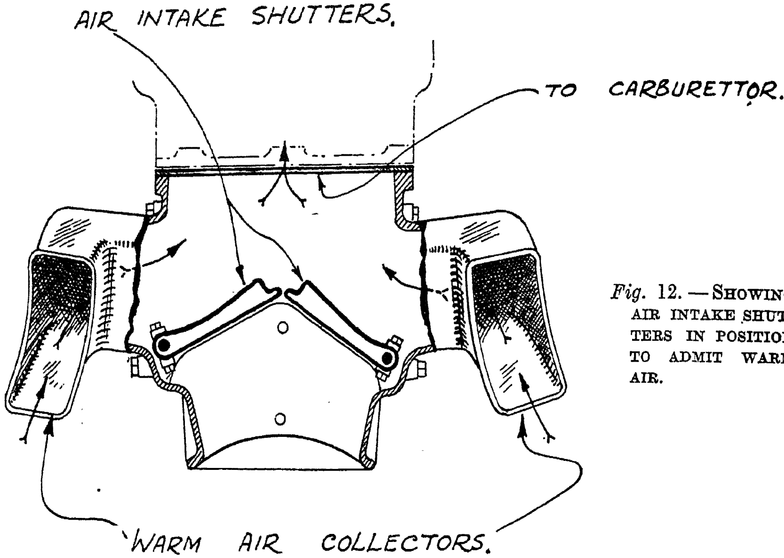


Fig. 12. — SHOWING AIR INTAKE SHUTTERS IN POSITION TO ADMIT WARM AIR.

and full power conditions such as take-off and climb, and also for normal cruising in dry, clear atmosphere the control should be in the position to admit cold air (see Fig. 11). For warming up, gliding and cruising in snow, rain, clouds or damp atmosphere, the warm air position should be used (see Fig. 12).

3. Use of V.P. Airscrew Pitch Control

For taxying, take-off, initial climb and for landing, the airscrew control should be in the fine pitch setting at which the airscrew develops high thrust at low air speeds.

To obtain maximum efficiency at altitude and high air speeds, that is for climbing above 1,000 feet and for all level flying conditions, the coarse pitch setting should be used.

The fine pitch setting should not be used in level flight as this will contribute to over-revving, and will adversely affect fuel economy.

Before stopping the engine the control should be put in the coarse pitch position as this will enable the ground engineer to carry out adjustments and routine inspection more readily.

4. Use of Cowling Gill Control

When controllable gill cowling is fitted the following may be taken as a general guide to the setting :—

Ground running, taxying . .	Open
Take-off and climb . . .	Open
Cruising	Closed

It is essential that the gills are fully open when ground testing the engine.

As the cowling gills control the amount of air circulating over the engine in flight, cylinder temperatures are directly affected thereby.

5. Cylinder Temperatures

On each engine provision is made for the attachment of a "Bristol" thimble couple which should be connected to a pyrometer mounted in the cockpit.

The temperature registered should not exceed the maximum permissible figures quoted below :—

Take-off and Climb maximum .	. 235° C.
All-out level maximum . .	. 235° C.
Cruising maximum . .	. 190° C.
Economy cruising maximum .	. 180° C.

If these temperatures are exceeded abnormal conditions are indicated, such as too weak a mixture, incorrect setting of cowling gills, incorrect fuel, etc. If the adjustments possible in flight do not bring the temperatures back to normal, the engine should be throttled back until the normal temperature is obtained, and on landing, the matter should be reported and the engine examined.

6. Oil Temperatures

In flight the oil inlet temperature should not exceed 70° C. for cruising, but for short periods during a climb a maximum inlet temperature of 80° C. is permitted.

7. Oil Pressures

With warm oil the pressure may drop below 70 lbs. per square inch during slow running and at speeds below 1,000 r.p.m., but the normal pressure of 80 lbs. per square inch must be maintained without fluctuation under normal flying conditions.

If the pressure falls below 70 lbs. per square inch during flight, the engine should be throttled back, a landing made and the cause of the low oil pressure investigated immediately.

After a First Flight

Generally examine the installation for fuel and oil leaks, tightness of main external nuts, etc., and see that all control connections are securely locked. It may be assumed that the airscrew and hub have settled down slightly due to running stresses, and these should accordingly be checked for tightness on hub and shaft respectively as previously described. Similarly in the case of a variable-pitch airscrew, ensure that it is tight on the shaft.

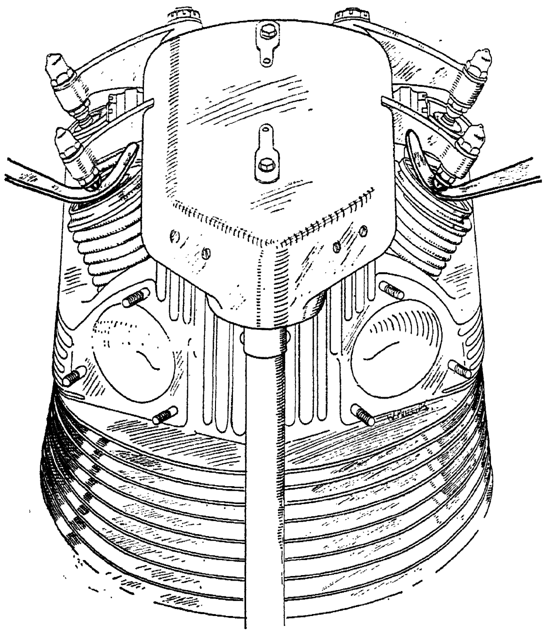


Fig. 13.—When setting valve clearances two sets of feeler gauges should be used simultaneously. Insert feeler between valve stem button and adjusting screw button and leave in position until adjusting screw has been tightened.

RUNNING ADJUSTMENTS

Setting Valve Clearances

Valve clearances must always be set with the engine cold. The following procedure will be found most suitable for service conditions :—

Remove one sparking plug from each cylinder to facilitate turning the crankshaft. Screw the T.D.C. indicator into the sparking plug hole of No. 1 cylinder and turn the airscrew until No. 1 piston is at top dead centre firing stroke, when all valves in this cylinder will be closed. Release the rocker adjusting screw lock-nuts and set the valve clearances to 0·004 in. on the inlet valves and 0·006 in. on the exhaust. The clearances should always be set on the highest portion of the cam base diameter, known as the "dwell," between the cams on the cam sleeve; owing to the manufacturing tolerances these may be found to vary very slightly. To determine the highest dwell, first set the clearances on No. 1 cylinder as described above, and then turn the airscrew shaft sufficiently to rotate the *crankshaft* through two complete revolutions in the normal direction of rotation, which will bring the next dwell on the cam sleeve into position for that cylinder. Now check the clearances again on No. 1 cylinder and continue to turn the crankshaft two revolutions at a time until all four dwells have been similarly checked. The highest dwell will give the lowest clearance reading, and the clearances on all cylinders must then be set on this dwell so as to ensure that the minimum required clearance is finally present. Care must be taken that both inlet valves are adjusted to the same clearance, and similarly that both exhaust valves are likewise adjusted. Two sets of feeler gauges should be used simultaneously. Insert the feeler gauge between the valve stem hardened

button and the rocker adjusting screw button and leave in position until the adjusting screw has been tightened (see Fig. 13). Re-check after tightening the lock nuts. After setting the clearances on No. 1 cylinder, remove the T.D.C. indicator and place it in No. 9 cylinder after which set the clearances on this cylinder in a similar manner. Continue around the engine in an anti-clockwise direction, dealing with each cylinder in turn, *i.e.*, Nos. 8, 7, 6, etc. To reduce the amount of turning of the airscrew to a minimum, it should be revolved in a clockwise direction facing the front of the engine.

Carburetter Adjustments

The carburetter is closely set by the manufacturers to suit all running conditions before it leaves the works, and as a fully equipped test-bed is necessary to effect any major adjustment, the tuning permissible when the unit is assembled to the engine in the aeroplane is necessarily limited.

All jet sizes are standardised, and no alteration must at any time be made, particularly in respect of the air-box jets.

Should faulty running or poor acceleration be experienced some advantage may accrue from a slight adjustment of the slow running screws as described below, although it is unlikely that any adjustment will be necessary unless the original settings have been disturbed or air leaks have developed.

In the first place it is essential that the engine be thoroughly warmed up to a temperature equivalent to normal flight conditions, after which it should be allowed to idle in the slow-running position for about five minutes and its behaviour after this period carefully observed. No signs of an excessively rich mixture, as indicated by black exhaust smoke and heavy thumpy running or loss in r.p.m. due to building up, should be present. At the same time the quality of the mixture must be such that it is possible to accelerate from the slow-running or any intermediate throttle setting, to the maximum ground level position without any signs of a flat spot or cutting out due to weakness.

Adjustments for Slow-running and Acceleration

The only adjustment permissible is that of the slow-running screws which are turned in a clockwise direction to enrich, and in an anti-clockwise direction to weaken the mixture. The effective range is approximately half a turn in either direction from the original setting, and further adjustment will upset the main tuning of the carburetter. Furthermore, it is important to note that adjustments must be made in very easy stages, particularly when weakening, so as to avoid the possibility of a backfire or flat spot.

Should a small alteration to the slow-running screws fail to effect a cure, the reason must be sought elsewhere. The induction system should be carefully examined throughout for air leaks, and in this connection

the induction pipe joints should receive close attention. Inspect the carburetter float chambers and ensure freedom from flooding; a high fuel level due to a defective float is a possible cause of building up in the induction system. Also examine the accelerator pump for leakages and ensure that the accelerator jet is free from obstruction.

A useful guide when examining the slow-running mixture strength is to run the engine at about 1,300 r.p.m. and see if it will continue to run with one magneto switched off. If, under these conditions, the engine cuts out this is a sure sign of a weak mixture, and an investigation should be carried out on the lines indicated above.

Automatic Boost Control Adjustments (Fig. 14)

The automatic boost control unit and its linkage are correctly adjusted and sealed by the engine makers and the seals should on no account be broken except by authorised persons.

Should any alteration in the setting be found necessary due, for example, to replacement parts having been fitted, the following instructions should be carefully observed.

Setting the Servo Piston Control Rod between the Boost Control and Toggle Links.—First ensure that the servo piston is pushed right up to the top of its stroke and retain it in this position during the subsequent operations. Next place the carburetter throttle lever in the open position and ensure that the toggle link lever is set to the full throttle position (with the pointer at the "F.T." marking on the quadrant plate). Similarly set the throttle spindle lever in the full open position against its stop. The servo piston control-rod eye should now centre with the holes in the toggle links; if the holes do not line up, an appropriate adjustment to the length of the control rod should be made. When making this check it is of the utmost importance that the piston is at the uppermost point of its travel, and that the levers are positioned as previously laid down. When the correct setting has been obtained the control rod is to be wired and sealed.

Setting the Variable Datum Control.—To set the variable datum cam the toggle-link lever, which is integral with the variable datum lever, should be set with the pointer at the "F.T." mark on the quadrant plate, when the scribed line on the port end of the cam spindle should be vertical and in line with the scribed lines on the bearing cap. The variable datum control rod is provided with an adjustable end to obtain this condition, and should finally be securely locked, wired and sealed.

Setting the Automatic Boost Control and Over-ride.—Having obtained the correct setting of the variable datum and piston control rods as described above, the boost control must now be set to give :—

(*a*) The rated boost pressure of $+ 3\frac{1}{2}$ lbs. per square inch.

(*b*) The take-off boost pressure of $+ 5$ lbs. per square inch.

The sequence of operations is as follows :—

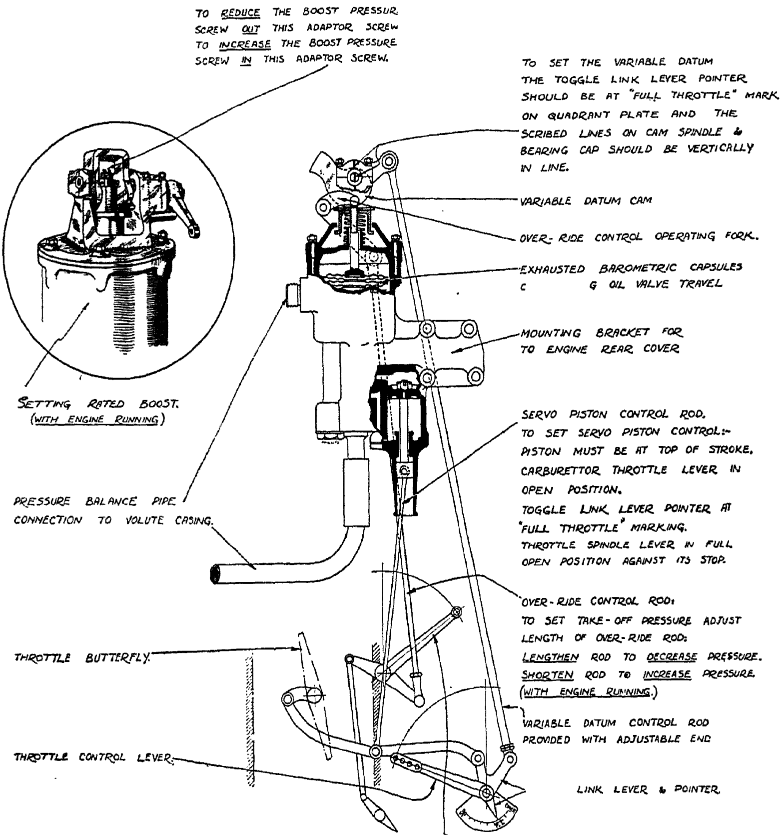


Fig. 14.—DIAGRAM SHOWING SETTING OF AUTOMATIC BOOST CONTROL. TO BE READ IN CONJUNCTION WITH INSTRUCTIONS GIVEN IN TEXT.

1. Assuming that the boost gauge has been checked against a standard barometer with the engine cold, and that it has been found to be within the specified limits, start up the engine and allow the oil to warm up.

2. With the mixture control lever in the normal position gradually open the throttle fully. The rated boost should be obtained at the full throttle position.

3. If, however, it is found that the boost is *above* the rated value, slow down the engine and screw OUT the diaphragm chamber screw adapter until, on opening up the engine again, the boost is reduced to the desired figure. Care should be taken during this operation, as the diaphragm, once set to gain control of the servo piston, requires only a slight movement of the adjusting screw to vary the boost pressure.

4. If it is found that the boost is *less* than the required value at the full throttle position, screw IN the screw adapter until the required rated pressure is obtained.

5. To set the final position of the over-ride control, place the mixture control in the "rich" position and gradually open the throttle until the correct take-off boost pressure is obtained. If the control is correctly set, no further increase in boost pressure should occur when the throttle lever is moved to the full throttle position.

6. Alteration in the take-off boost pressure is effected by adjustment of the over-ride control rod, the rod being *lengthened* to *decrease* the boost pressure and *shortened* to *increase* same. When the engine is throttled down to make adjustments it is necessary to return the mixture control lever to the "normal" position. It should be noted, however, that in the event of any alteration to the setting of the over-ride control rod being found necessary it is essential that a new rod be fitted as the adjustable end is locked by wire passing through a hole which is drilled through the rod threads after the length has been set; in no circumstances may a rod be drilled twice. New rods are supplied undrilled, and must be drilled, locked and sealed after the correct setting has been obtained.

7. When running up on the ground with a flight (fixed pitch) airscrew which holds the engine r.p.m. much below normal, a minimum speed of 2,050 r.p.m. must be obtained before maximum boost can be attained.

8. In the event of a variable-pitch airscrew being fitted, the blades should be set in the fine pitch position, and when the engine has reached its maximum take-off r.p.m., viz. 2,650, the boost gauge should register + 5 lbs. per square inch. Any correction necessary is made by an appropriate adjustment of the rod as before.

9. Owing to the fact that the engine does not receive its normal cooling airstream until it is in flight, a maximum duration of ten seconds at full throttle must be rigidly observed.

10. After setting the rated and take-off boost, the diaphragm screw and control rod should be securely locked, wired and sealed.

ROUTINE MAINTENANCE SCHEDULE

Regular and proper maintenance is of primary importance, and close observance of the schedule requirements is essential if the maximum efficiency and freedom from trouble is to be obtained.

It is, however, impossible to lay down hard and fast rules, and owing to the wide possible divergences in operating conditions, requirements will be largely dependent upon the nature of the work or route upon which the engine is employed. The periods given hereunder are typical for normal service conditions, and before departing from them the advice of the manufacturers should be obtained. Furthermore, they must not be interpreted as absolving any mechanics concerned from the respon-

LUBRICATING AND GREASING CHART

Greasing and Oiling Points.	Recommended Brands.	Greasing and Oiling Periods.
Rocker adjusting screws.	Stanavo, No. 2 grease.	When assembling and every 20 hours.
Rocker buttons (early engines).	Stanavo, No. 2 grease.	When assembling and every 20 hours.
Rocker bearings .	Stanavo, No. 2 grease.	When assembling and every 120 hours.
Rocker felt pads .	Mineral oil, Specification D.T.D. 109.	When assembling and every 120 hours.
Valve stem button lubricating pads.	Mineral oil, Specification D.T.D. 109.	When assembling and every 40 hours.
Spark plug threads .	Graphite and grease.	When fitting.
Blower gears and bearings.	Mineral oil, Specification D.T.D. 109.	*Before starting:* If engine has been standing more than 5 days in moderate atmospheric temperatures; after 48 hours idleness in air temperatures about 5° C.; after standing overnight in air temperatures of 0° C. and below.
Gun gear . . .	Lanoline.	Every time guns are used.
Generator drive .	Graphite and Price's grease (high melting point Belmoline).	On assembly and every 120 hours.
Airscrew shaft .	Graphite and grease or Whitmore's compound.	When assembling airscrew hub.
Single type fuel pump	Stanavo, No. 2 grease.	Every 40 hours.
Carburetter linkage .	Mineral oil, Specification D.T.D. 109.	Every 120 hours.
V.P. airscrew . .	Temperate climate—Mobilgrease No. 2. Cold climate—Mobilgrease No. 1.	Every 10 hours.
Air intake shutter spindles.	Stanavo, No. 2 grease.	Every 40 hours.
Magneto . . .	Magneto oil or thin machine oil.	Every 40 hours.
Magneto contact breaker.	Magneto oil or thin machine oil.	Every 40 hours.

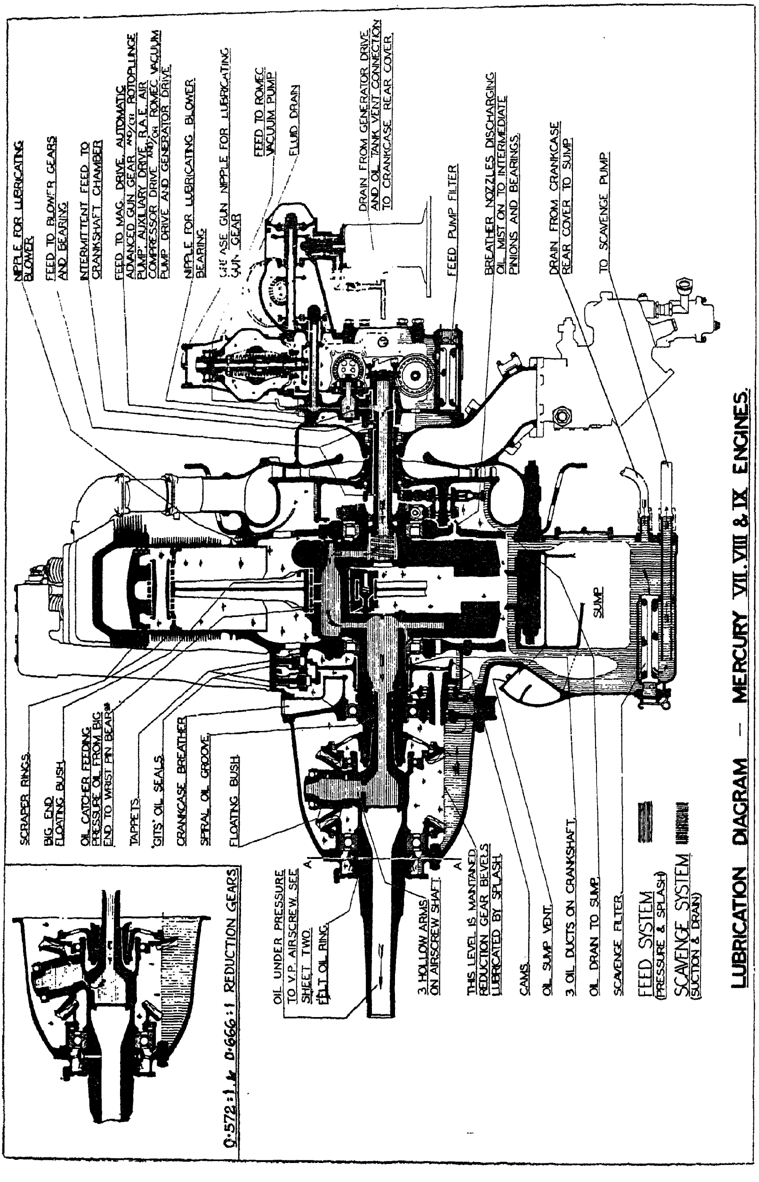


Fig. 15.—LUBRICATION DIAGRAM.

sibility of acting upon any circumstances indicating the need for additional operations.

In the case of proprietary accessories such as electric and inertia starters, air compressors, etc., the maintenance recommendations of the manufacturers should be observed.

After Each Day's Flight

1. Examine the pilot's report and in the event of there being any remarks regarding abnormal engine running, carry out the necessary adjustment forthwith.

2. See that the ignition switches are in the "OFF" position.

3. Generally examine the fuel and oil systems for obvious leaks. See that all unions are properly locked, and that the flexible joints are intact and in good condition. Inspect all fuel pump plugs, etc., for security and fuel tightness.

4. Clean out the fuel filters.

5. Replenish the fuel and oil tanks if necessary, and see that the filler caps are properly secured.

6. Inspect all engine controls and see that locking devices are intact.

7. Check tightness and locking of all main nuts and bolts.

8. Carry out a careful visual examination of the valve gear; see that all valve springs are intact and that the hardened buttons pressed into the end of the valve stems are secure. If excessive wear of stem buttons is found, examine the corresponding adjusting screw thrust button for sticking, as this is the most likely cause of the trouble developing; both should be replaced if wear is apparent.

9. Examine all H.T. leads and see that the sparking plug connections are secure.

10. Test the throttle and mixture controls, also the air intake shutter and slow running cut-out controls for freedom of movement.

After each 10-Hours' Running. (In addition to daily adjustments.)

1. Remove the filter in oil sump and examine for metallic particles; clean and replace. The presence of metallic particles in suspension with the oil, indicates some abnormal condition, and the cause should be investigated immediately.

2. Check over the exhaust system, pipe joints and fastenings and ensure that the required amount of freedom is present in the exhaust pipe joints.

3. If a variable-pitch airscrew is fitted, lubricate the blade spindle bearings through the nipples provided, using Mobilgrease No. 2. In very cold climates Mobilgrease No. 1 may be used. Clean and lubricate the exposed portion of the piston, using the same grease. This should be done with the blades in the fine pitch position. Remove the counter-

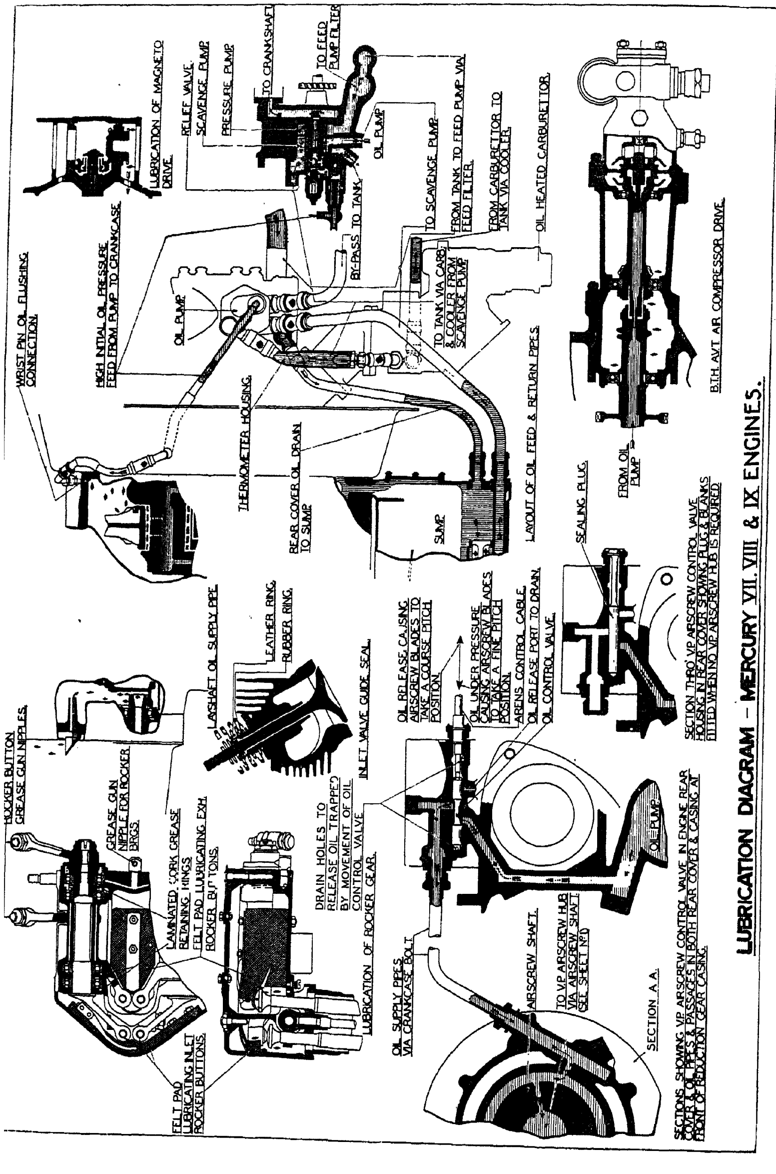


Fig. 16.—LUBRICATION DIAGRAM.

weight bearing cap and smear bearings with same grease. Examine the hub for any signs of oil leaks past the leather washer.

4. Check by hand the clearances of all valves, and if considered excessive, reset in accordance with the instruction given on p. 466.

After each 20-Hours' Running. (In addition to daily and 10-hour adjustments.)

1. Examine rocker adjusting screw-thrust buttons for excessive wear.

2. Remove rocker bracket covers and inspect the tie rod bolts and rocker fulcrum for signs of slackness. Replace bolts if necessary. Also examine the push-rod upper ends.

3. Remove, clean and reset the gaps on all sparking plugs; when replacing, fit new rolled-copper type washers where necessary; smear the threads lightly with a mixture of graphite and grease.

4. Lubricate the rocker adjusting screws with approved grease.

5. Check the compression on each cylinder. To carry out this check, remove one sparking plug from each cylinder except the cylinder being tested. On completion of test, remove one plug and fit into the next cylinder to be checked, and so on until each cylinder has been tried in turn. In the event of a cylinder being found with weak compression, it should be removed and the cause located.

6. Examine magneto contact breakers, check points for condition and gap and rocker arms for freedom.

7. Disconnect the fuel pipes at the carburetter and flush out the system. Reconnect pipes and wire lock where necessary.

After each 40-Hours' Running. (In addition to daily, 10 and 20-hour adjustments.)

1. Drain the oil from the tank, pump system and sump. This should be done whilst the oil is hot to ensure complete draining. Flush out the oil tank with flushing oil or paraffin. In the event of paraffin being used, a final flushing should be carried out with clean petrol. Do not, in any circumstances, allow petrol or paraffin to enter the engine lubrication system, and make sure that the tank and oil system are clear of petrol and paraffin before refilling with new oil.

2. Examine oil cleaner for metallic particles and general cleanliness.

3. Drain and clean the oil cooler in a similar manner to that described above for the tanks.

4. Lubricate the magnetos in accordance with the instruction given on the magnetos.

5. Examine and clean magneto distributor.

6. Remove carburetter float chamber base plugs and clean chambers; examine for water deposit.

7. Lubricate the felt pads in the valve spring upper washers, using engine oil D.T.D.109.

8. Inspect and calibrate boost gauge in accordance with the standard

instructions regarding the maintenance of this instrument. It is most important that this instruction is adhered to at the periods stated.

9. Lubricate single type fuel pump bearings. Check the union nuts and locking devices, also the relief valve cap for security on both single and dual type pumps.

10. Inspect the variable-pitch airscrew for tightness on airscrew shaft, using spanner provided. Re-lock after re-tightening in the approved manner. If a wooden airscrew is fitted, remove airscrew and hub. Examine the split taper collet, also the splines in the hub or on the airscrew shaft. Tighten the hub bolts and re-split pin. After reassembly, ensure that the hub is tight on the shaft and that all locking devices are secure.

After 120-Hours' Running. **(In addition to daily 10-, 20- and 40-hour adjustments.)**

1. Charge the rockers with approved grease until discharging around the bearings, using grease gun provided. Wipe away surplus lubricant.

2. Remove the rocker covers carrying the inlet felt pads, also remove the exhaust felt pad from the bottom of each rocker bracket and submerge in a bath of engine oil (D.T.D.109) at 50° C. for a minimum period of one hour. After soaking, remove from bath and drain off all surplus oil. Re-fit the pad to the bottom of the rocker bracket and replace the rocker bracket cover. Care should be taken to segregate each pad to its respective cylinder, since on initial assembly each is fitted to give a specific lift. When fitting new inlet and/or exhaust felt pads, careful check must be made to ensure that the total lift of each pad is within the limits of 0·100 in. to 0·200 in.

Note.—In no circumstances should the pads be washed, and only when replacement becomes necessary should the inlet pad be removed from the rocker bracket cover.

3. Remove the felt pads from the valve spring upper washers and soak them in engine oil in a similar manner to that detailed above for the rocker pads.

4. Replace the Tecalemit oil filter element.

Weekly Maintenance

Every week the engine should be thoroughly inspected, all nuts tightened, locking devices replaced where necessary, particular attention being paid to the following :—

1. Carefully examine all fuel and oil connections, particularly those on the suction side of the fuel and oil pumps.

2. Examine all controls, see that they are properly locked and pins unworn.

3. Lubricate the control rod fork-ends and bulkhead slides.

4. Examine engine mounting securing nuts and bolts, particular attention being paid to flexible mounting units when fitted.

5. In the case of engines fitted with 14 mm. sparking plugs, both the sparking plug and adapter should be inspected for tightness.

Overhaul Periods

The length of periods between overhauls is dependent on the operating conditions. The engine manufacturers will be pleased to give operators their recommendations in this connection on receipt of full details of their operating and climatic conditions, such as revolutions per minute, altitude and boost pressure employed for cruising. Particulars should also be given of the fuel and oil used, also the cylinder temperatures reached on climb and under cruising conditions.

Rocker Mechanism Felt Lubricating Pads.

Special Maintenance Note.—The rocker mechanism felt pads should not normally require re-soaking until the 120-hour routine inspection period as specified above. If, however, the aeroplane is operated spasmodically and the period of time elapsing between each 120-hour inspection exceeds one month, the felt pads should be soaked every month in order to counteract the normal drying of the felt.

KESTREL SERIES V AERO-ENGINE

RUNNING AND MAINTENANCE

By WING-COMMANDER F. A. NORTON, M.Sc., M.I.Mech.E., M.I.Ae.E.

Definitions

THE Kestrel V aero-engine is manufactured by Rolls-Royce Ltd., and is of the " V " type in banks of six cylinders at 60°, geared, composite cooled, fully super-charged and fitted with automatic boost regulator.

The purpose of this section is to describe running and maintenance under these headings, taking into account the characteristics of this engine as described in Volume II, and the differences for operation in high, moderate and low-temperature climates.

Further Leading Particulars

Fuel

The fuel must have an octane value of not less than 87, as given by the modified motor method employed by the co-operative fuel research committee of America. This applies to all climates. The specification recommended is that issued by the British Air Ministry through the Directorate of Technical Development, No. 230, the leading particulars of which are as stated below :—

Description.—The standard fuel for aero-engines shall consist of high-grade petrol prepared from crude petroleum, coal spirit or mixture thereof.

The fuel as a whole shall be neutral, clear, free from undissolved water and any suspended matter.

In order to obtain the necessary anti-detonation value as specified in the clause below, it is permissible to add aromatic hydrocarbons and/or tetra-ethyl-lead in the form of 1T ethyl fluid in concentrations not exceeding 4 ml. of tetra ethyl lead per imperial gallon.

The extent of such additions will be governed by the succeeding clauses of this specification.

Distillation Range.—When 100 ml. of the fuel submitted are distilled in the standard distillation apparatus, there shall distil at 760 mm. pressure :—

Below 75° C. not less than 10 per cent.
At 100° C. not less than 50 per cent.
At 150° C. not less than 90 per cent.
The end point shall not exceed 180° C.
The distillation loss shall not exceed 2 per cent.
The total volume of distillate collected in the receiver shall not be less than 96 per cent.

Vapour Pressure.—The vapour pressure as determined by the Reid method at 37·9° C. (100° F.) shall not exceed 7 lb. per square inch.

Specific Gravity.—The specific gravity at 15° C. shall be not more than 0·79.

Sulphur Content.—There shall be a complete absence of free sulphur when determined by the copper strip method, and the total sulphur content shall not exceed 0·15 per cent. by weight.

Freezing Point.—The freezing point as indicated by the initial formation of solid shall be not higher than − 60° C.

Gum.—(*a*) *Existent Gum.*—The amount of existent gum as determined by the evaporative method in a glass dish shall not exceed 10 mgms. per 100 ml.

(*b*) *Potential Gum.*—After 50 ml. of the fuel have been incubated at 35° C. for twenty hours, the increase of gum yield over and above the existent gum as determined by the evaporative glass dish method shall not exceed 10 mgms. per 100 ml.

Anti-detonation Value.—The anti-detonation value shall be not less than 87 octane number when determined by the standard " Co-ordinated Fuel Research motor method " modified so that the unit is run with a mixture temperature of 260° F.

The octane number is numerically the percentage of volume of iso-octane (2, 2, 4, tri-methyl pentane) in a mixture of iso-octane and normal heptane. The octane number of the fuel is the octane number of the mixture of iso-octane and normal heptane which it matches in anti-detonation value.

A secondary or sub-standard reference fuel may be used for purposes of matching, but the sub-standard fuel must be equal in knock rating to the primary octane-heptane mixture when tested under the conditions specified. Supplies of standard or sub-standard fuels will not be issued by the British Air Ministry, who will use as a sub-standard a straight-run petrol of high knock rating with the addition of pure crystallisable benzene when undoped fuels are being tested and the addition of tetra ethyl lead when fuels containing tetra ethyl lead are being tested.

Note.—Three comparisons of the sample with the reference fuel are to be made. The sample, on the average of these comparisons, shall not be inferior to the standard. Frequent calibrations of the secondary reference fuels against the primary octane-heptane standard must be made.

Colour.—When tetra-ethyl lead is used as an anti-detonant, the fuel must be coloured noticeably blue with a suitable dye to distinguish the leaded fuel from those not so doped.

Tests.—The fuel shall pass prescribed tests as laid down by the Institution of Petroleum Technologists.

Consumption at international power (pints/b.h.p./hr.) 0·55.

Capacity of System.—According to range of action required.

Oil

The oil must be mineral lubricating oil denoting pure highly refined petroleum oils free from adulterants. The specification recommended is that issued by the British Air Ministry through the Directorate of Technical Development No. 109, the leading particulars of which are stated below :—

Definition.—The term mineral lubricating oils shall denote pure highly refined petroleum oils free from adulterants.

Appearance.—The oil shall be clear and free from dirt, suspended matter, water and any other impurities.

Viscosity.—The absolute viscosity shall be :—

Summer Grade.
At 100° F. not more than 2·9 poise.
At 200° F. not less than 0·183 poise.

Winter Grade.
At 100° F. not more than 1·75 poise.
At 200° F. not less than 0·133 poise.

Flash Point.—The " open " flash point shall be not less than 199° C.

Free Acid.—The oil shall contain not more than a trace of mineral acid and not more organic acid than corresponds to 0·01 gm. caustic soda per 100 gm. of oil.

Ash.—The ash content shall not exceed 0·01 per cent. by weight when tested.

Oxidation.—After blowing for twelve hours the viscosity at 100° F. shall be not greater than 2·0 times the original viscosity at the same temperature.

Coke Number.—(*a*) The coke number shall not exceed 0·70.

(*b*) The coke number of the oil after twelve hours' blowing shall not exceed the original coke number plus 1.

Coldness.—The oil shall not cease to flow when exposed for one hour to the following temperatures :—

For summer oil – 8° C. (17·6° F.).
For winter oil – 10° C. (14° F.).

Note.—The last six items shall be based on prescribed standardised methods of testing.

Summer grade oil must be used for high and moderate temperature climates.

Winter-grade oil must be used for low-temperature climates down to – 15° C., and below this temperature specially low-temperature graded oils.

Consumption (pints per hour), 4 to 8.

Capacity of system according to radius of action of fuel + a factor of safety + sufficient air space in the tank to guard against possible losses by overflowing according to specified aeroplane performance.

Engine inlet temperature—minimum for take-off 20° C.
" " " maximum for flight, 90° C.
" " pressure—normal, 45–60 lbs. per sq. inch.

Grease

Used for the cooling liquid pump gland and generator cables, must be oxidised oil to specification D.T.D. No. 109, described above.

Cooling Liquid. Water

Generally water is used, but it must be pure, *i.e.*, as distilled. Chlorinated water is most unsuitable owing to the danger of corrosive action taking place on the aluminium alloys with which it is in contact.

Anti-Freezing Mixtures

If anti-freezing mixtures are used those with a glycerine base are unsuitable owing to frothing and turbulenting tendencies causing excessive losses. The most satisfactory mixture is one containing 30 per cent. ethylene glycol with 70 per cent. pure water. This mixture, however, has a tendency to attack rubber, and if used necessitates a more frequent inspection of the rubber joints in contact.

For high temperature climates this tendency is stronger owing to the more rapid deterioration of rubber in such climates, and as freezing has rarely to be considered the use of this mixture is not recommended.

Other Liquids

If other cooling liquids are used they must be anti-corrosive in substance, *i.e.*, not containing any corrosive agent or rubber-attacking tendencies, but they may have higher boiling points (an attractive feature).

Consumption.—Topping-up only for any loss in flight due to evaporation.

Capacity of Water or Anti-Freezing Mixture System

Twelve and a half gallons for moderate- and low-temperature climates. For high-temperature climates the capacity of the radiator is 1 gallon extra to allow an increased cooling area, making 13½ gallons in all.

Maximum climbing flight temperature—
Composite cooling . . . . 110° C.
Maximum level flight temperature—
Composite cooling . . . . 94° C.
Other liquids. Maximum temperatures according to liquid used.

Note.—Only the composite system has been considered generally for this engine. (See Fig. 11, Vol. II., p. 282.)

Ignition

Specially designed ball-ended aero plugs of the following types are recommended: Lodge A.5/B; K.L.G. V7/3B; K.L.G. V9/1B. Electrode gap 0·012 in.

Specially designed magnetos of either the rotating armature or polar inductor types must be used, each with 12-point distributors, the type usually fitted being the Watford S.P. 12–3. Contact breaker gap 0·012 in., timing for the fully advanced position being 37° before T.D.C.

Valve Operation

Timing. Inlet opens 12° before T.D.C., closes 40° after B.D.C.
Exhaust opens 50° before B.D.C., closes 2° after T.D.C.

Exhaust and inlet tappet clearances 0·020 in., cold setting.

RUNNING

To describe the various types of installations is not part of this article, therefore the assumption may be made that the engine is installed and ready for running with all adjustments made. Installation is treated as part of complete overhaul to be given in a later section.

Hand Cold-starting, Moderate and High Temperature Climates

The hand priming pump is used whilst the engine is turned slowly by engaging the hand starter gearing. For one revolution of the engine, two or three strokes of the priming pump plunger is a fair average with the main mixture supply lever at the closed position on the quadrant. After two revolutions the main mixture supply lever is opened a little and the ignition is switched on, *i.e.*, both magnetos and a hand-starting magneto, the high-tension lead of which is connected to the distributors of both magnetos.

As soon as the engine starts, the hand-starting magneto and priming pump are switched off.

Hand Hot-starting. All Climates

When starting a hot engine priming should not be necessary. The engine should start on being turned by the hand starter with the hand-starter magneto in operation and the main mixture supply lever a little open. If priming has to be used not more than two strokes of the hand pump should be given.

Hand Cold-starting. Low-temperature Climates

If cooling liquids are used which are liable to freeze under cold housing conditions the system will have been drained, and in this case heating before refilling is recommended, the procedure for starting being as described above.

When non-freezing liquids are used the starting procedure as described

above may not produce easy starting especially in extreme cases, one or both of the two methods described below may be adopted :—

1. Take out one plug from each cylinder, preferably the exhaust side, warm and replace. For long periods of rest this set of plugs should be taken out just after the engine is stopped and stored in a warm dry place—a hot oven if one is available, dummy plugs being fitted for protection.

2. Take out six plugs, one from each of alternate cylinders, and insert one dessert spoonful of warm engine oil, replacing the plugs as quickly as possible.

Proceed as described under hand cold-starting.

Gas Starting. All Climates

As the pressure used may be anything between 80 and 200 lb. per sq. in., priming can be commenced as soon as the engine starts to turn. Procedure is then as described under hand cold-starting and the gas starter is switched off as soon as the engine starts.

Generally

Note.—Individual engines vary for the amount of priming required. Excessive priming should be avoided, it is better to under-prime than over-prime.

Over-priming may be cleared by opening the main mixture supply lever slowly to the full position and turning the airscrew backwards if possible, if not forwards.

Note.—Engaging the hand starter must be carefully done. Pull the engaging rod or cable to bring the worm into mesh with the worm wheel at the same time slowly rotating the starting handle until a decided increase in load is felt. This corresponds with full meshing of the worm and worm wheel and the engaging rod or cable should then be released, as it must never be held whilst the engine is being turned. If it is, the worm would not be free to unmesh in the event of the engine starting, and damage would occur.

Note.—Whilst priming, the engine should always be turned as slowly as possible and the speed increased as soon as the ignition is switched on and the hand-starter magneto used.

Warming. All Climates

With the engine started, the importance of all cylinders firing evenly if intermittently cannot be overstressed. The oil pressure must build up immediately, and slow running, say 600 to 800 r.p.m., should not be carried out for more than two minutes. The r.p.m. should then be increased by slowly advancing the main mixture supply lever to 1,200 to 1,400 r.p.m., according to the most even running for the engine concerned. If possible, all cylinders should be firing evenly. In any case, intermittent firing should be reduced to a minimum.

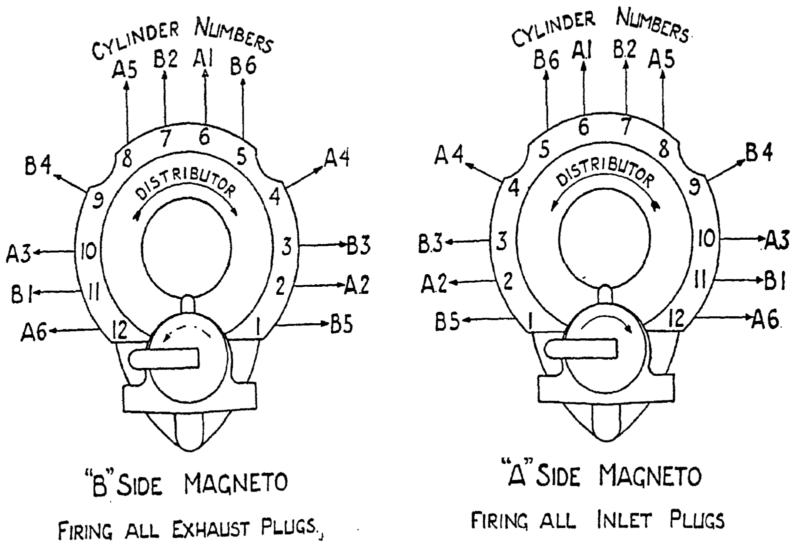


Fig. 1.—THE IGNITION SYSTEM MARKING.

This engine speed is maintained until the oil temperature is not less than 20° C. and the cooling liquid temperature is about 65° C.

No stated time can be given for this warming period, existing conditions are the governing factors. Opening up too soon, however, is likely to produce excessive loading due to comparatively extreme and irregular temperatures and correspondingly more wear. The temperatures should therefore be sufficiently near stable running conditions to avoid excessive loading. The time may be governed by the judicious use of radiator exposure adjustment.

Ground Testing the Engine. All Climates

With the engine heated to running temperature, the main mixture supply lever is slowly moved up to the gate position. The following tests should then be made :—

Ignition.—At normal r.p.m. running on the " A " side magneto only (see Fig. 1), the drop in r.p.m. should not be more than 2 per cent., whilst running on the " B " side magneto only, the drop should not be more than 5 per cent.

Carburation.—A smooth acceleration should be given with no signs of cutting out or erratic periods. The fuel pressure gauge should be steady at 2 to $3\frac{1}{2}$ lb. per sq. in. (maximum permissible 4 lb. per sq. in.).

The rated boost pressure should be correct as shown by the gauge.

The fuel valve control lever for strengthening and weakening the mixture with altitude should be opened to test the drop in r.p.m., which should not be more than 5 per cent.

Cooling.—Sudden rises in temperature as shown by the gauge should not occur. The temperature should rise steadily to about 75° C. and be controlled by radiator adjustment, *i.e.*, amount of radiator exposure to slip stream. No signs of steam or vapour emission should be observed.

Lubrication.—Steady normal pressure, 45 to 60 lbs. per sq. in., should be shown by the gauge with a slowly increasing temperature.

General.—The r.p.m. should be checked to give not less than 75 per cent. of the normal.

The engine should not be run for the above tests for more than two minutes.

Closing the main mixture supply lever to the slow-running position should give a smooth deceleration without cutting out or erratic periods.

Slow running periods with the engine at working temperature should be as short as possible and never more than a few minutes, owing to the slow circulation of the cooling liquid which allows excessive differences of temperatures in the system. Should the engine be opened up in this condition carburation must be affected, which may result in cutting out with sudden increase of loading.

Taking Off

On take-off with the main mixture supply lever passed through the gate to its fully opened position, see that the maximum take-off boost is not exceeded and that the minimum r.p.m. are registered on the gauge. This position must not be maintained for more than three minutes or after climbing 1,000 ft., whichever is the lesser.

The Engine Airborne. Moderate and Low Temperature Climates

After taking off with the engine airborne and the main mixture supply lever returned to the gate position, the following checks should be made:—

Carburation.—Maximum boost pressure and r.p.m. for climbing flight * $+ 1\frac{1}{2}$ and 2,500 respectively.

The rated altitude of 11,000 ft.

Maximum boost pressure and r.p.m. for all-out level flight $+ 1\frac{1}{2}$ and 2,900 respectively.

Maximum boost pressure and r.p.m. for continuous cruising $+ \frac{1}{2}$ and 2,500 respectively.

Permissible boost pressure for economical cruising $+ \frac{1}{4}$ with $2\frac{1}{2}$ per cent. drop in r.p.m.

Fuel pressure gauge steady at 2 to $3\frac{1}{2}$ lb. per sq. in.

Cooling.—Variation of temperature by radiator adjustment with composite cooling, the maximum permissible temperatures are 94° C. for level flight and 110° C. for climbing flight.* General conditions will allow an average of 85° C. to be easily maintained.

Lubrication.—Steady normal pressure 45 to 60 lb. per sq. in., with a temperature not more than 80° C.

* Climbing flight should be the best climbing air speed of the aeroplane concerned as given by the makers.

The Engine Airborne. Hot Climates

The two systems requiring special treatment in hot climates are cooling and lubrication.

Carburation may be checked as for moderate and low temperature climates.

Cooling.—Check maximum temperatures of 110° C. and 94° C. in climbing and level flight respectively. Remember that the boiling point drops with increasing altitude and allowance must be made for this to avoid loss due to excessive evaporation. Whilst checking these temperatures the correct working of the header tank must be watched. A surging temperature gauge is an indication of excessive vapourisation which, if allowed to continue, may give emission from the header tank. Any such loss must be stopped by radiator adjustment or changing the attitude of the aeroplane if the radiator is in the fully exposed position.

Lubrication.—A minimum oil pressure of 30 lb. per sq. in. and a maximum temperature of 90° C. is permissible, both as registered on the gauges. Running continuously at this pressure and temperature is most inadvisable, and may be overcome by fitting additional elements to the oil cooler until the temperature is reduced to 80° C. and pressure increased to normal.

Generally.—The engine should be running smoothly and without excessive vibration.

After Flight.—When stopping the engine after flight the speed should be reduced to slow running for a short period, say one minute, and switched off at that speed. This is to regularise the temperature throughout the engine, otherwise it may continue to run under the influence of irregular and violent impulses which throw excessive stresses on the various moving parts.

Stopping the engine by turning off the fuel cock and running out the fuel is most inadvisable, owing to the irregular firing on starvation.

MAINTENANCE

Running faults and their remedies are being treated generally in a separate article.

The extent and sequence of the treatment for normal maintenance * is described under the following headings common to all climates unless specified :—

1. Before flight, or daily if under 5 hours' flying.†
2. After 10 hours' flying.
3. „ 20 „ „
4. 40
5. 120
6. 480

* The word "inspect" is intended to include any necessary attention.

† Flying hours have been chosen as the basis of maintenance on the assumption that storage or rest periods are reasonably short, say not more than forty-eight hours.

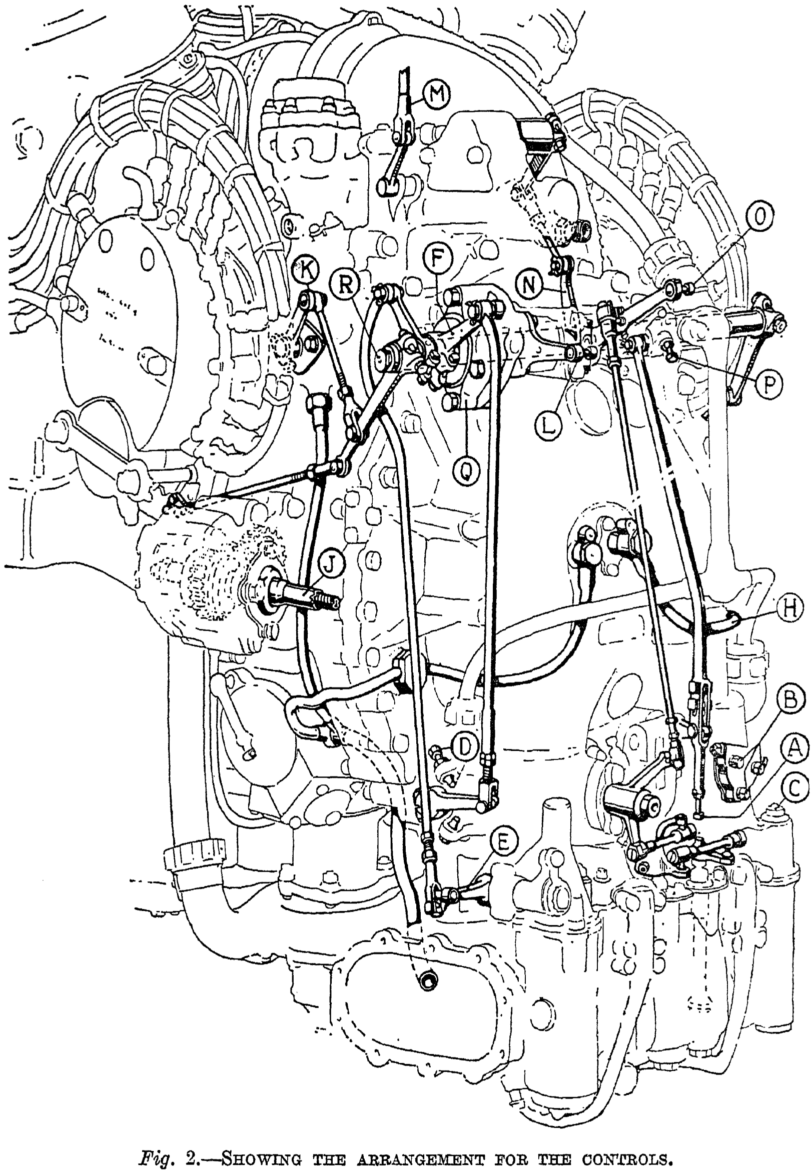


Fig. 2.—SHOWING THE ARRANGEMENT FOR THE CONTROLS.

1. Before Flight or Daily

Test the airscrew hub for slackness.

Note.—This can be done by feeling lightly on the tip of the airscrew

blade. After initial attachment the airscrew should be examined for tightness after the first two or three flights.

Inspect the cylinder blocks for any trace of water leaks.

Inspect all high tension cables and sparking plug connections for security.

Inspect all pipe lines and unions of all systems. Cocks should be in the " on " position for this inspection.

Test all controls for tightness.

Inspect the cooling system for any loss due to evaporation, check the regularity of any such losses.

Note.—For low-temperature climates, if the system is emptied care must be taken to see when filling that no air locks are possible. With the radiator in the fully exposed position the air vent cocks on the engine should be open until the coolant flows from them and after closing with the header tank filled to the correct level the exact quantity should be checked by comparison to the standard. The attitude of the aeroplane must be correct, consistent with the air vents being at the highest parts of the system.

Screw down the cooling liquid pump lubricator one turn. Should leaks occur at gland, screw gland nut up slightly *by hand* when engine is hot.

Replenishing the fuel and lubricating systems is taken for granted.

After 10 Hours' Flying

Remove and clean the following filters :—

Oil, on pressure pump suction.

Oil, on front and rear scavenge pumps suction (see Lubrication, Volume II., p. 285).

Fuel, on pump suction (see carburation, Volume II., p. 273).

Note.—No rag should be used for cleaning the filters, and all joint surfaces should be cleaned before assembly.

Lubricate all controls. With " Tecalemit " oil gun force oil (Specification D.T.D. 44.B) through lubricator on main control shaft (Fig. 2, letter R).

After 20 Hours' Flying

Disconnect and flush out the fuel piping which connects the main filters to the carburetter.

Examine flexible fuel piping for resinous deposit. If any is found the piping should be renewed.

Disconnect and clean the priming system.

Remove and clean the slow-running filter (Fig. 3).

Inspect the radiator control gear for correct operation and lubricate where necessary.

Note.—If ethylene glycol is used as the cooling liquid all rubber connections should be inspected for serviceability.

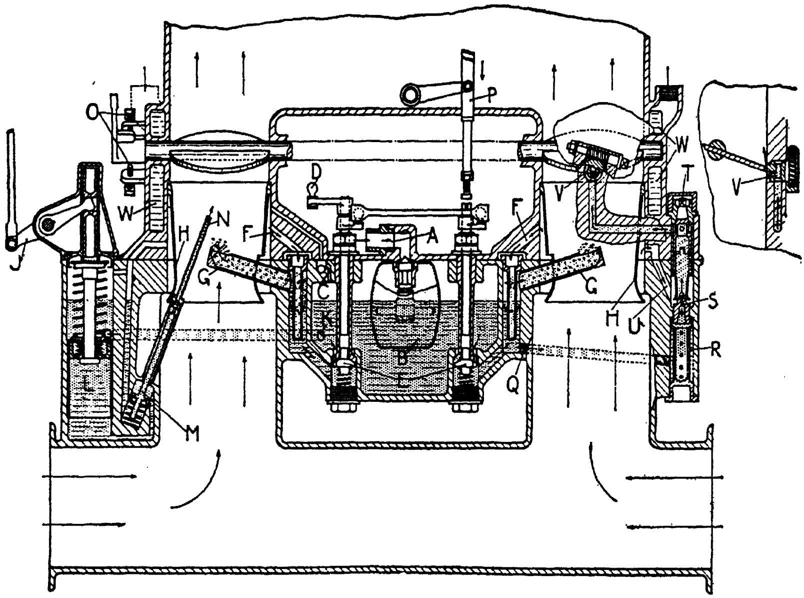


Fig. 3.—SHOWING A SECTIONAL ARRANGEMENT OF THE CARBURETTER.
The slow-running filter is shown at R.

After 40 Hours' Flying

Magnetos

Gaps of contact breaker points should not exceed 0·013 in. minimum, 0·011 in. with rocker on peak of cam. They should be clean and free from pitting. Rocker arm to have easy movement on pivot.

Clean distributor and contact breaker covers and check clearance of distributor points. (A dummy distributor will be necessary.) Distributor segments should be free from pitting. Contact breaker cover spring should be in good condition with good contact for the low-tension socket.

Check the advance and retard movement for correct working.

Lubricate with a few drops of magneto oil in the places provided as per the instructions stated on the plates attached.

Clean the contact breaker housing and spigot and lubricate with a good high melting-point grease.

Sparking Plugs

Remove, dismantle and clean sparking plugs. Re-set gaps to 0·012 in. maximum 0·015 in. if contact breaker points gap is the maximum, and test under pressure of 100 lb. per sq. in.

Wiring

Inspect all cables for serviceability.

Test all insulation, bonding and screening.

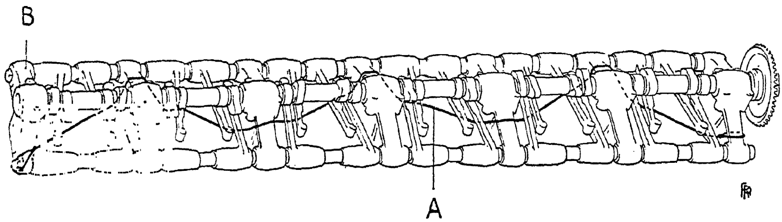


Fig. 4.—METHOD OF SECURING ROCKER MECHANISM (TEMPORARILY).

Lubrication System

Drain, clean, examine and refill with fresh oil. Draining should be carried out when the oil is hot. The oil so drained should be examined most carefully, as it indicates the internal condition of the engine. Any sludge should be collected and analysed. The nature of any metal particle should be obtained by chemical test as follows :—

Clean in petrol and dry. Spread the metal out in a shallow dish and pour over a 10 per cent. hydrochloric acid solution cold (standard dilute solution) or 10 per cent. caustic soda cold.

If duralumin or aluminium alloy, the metal shavings will be visibly attacked. Lead or white metal (also bronze) will show no visible reaction. The particles may, of course, be a mixture of both duralumin and lead or white metal. If well spread out, as indicated, these reactions will be observed.

When not in use the acid solution must be kept in a properly stoppered bottle, and when in use care must be taken, as any fumes will attack any neighbouring exposed steel parts by corrosive action.

Dismantle and clean all relief valves.

Note.—Great care must be taken with all joint surfaces, which must be clean and new washers fitted if necessary before assembly. Excessive tightening to secure a good joint must be avoided.

Valve Gear

Inspect the valve springs for fractures and valve ends for damage.

Inspect the camshaft and valve rockers for wear.

Check tappet clearances and reset if necessary to 0·020 in. cold.

Generally

Check the holding-down bolts of the engine for tightness.

Note.—If rubber packing is used its condition should be inspected.

Inspect all rubber connections for serviceability.

Note.—If ethylene glycol mixture is used for the cooling liquid this should be carried out after 20 hours.

Inspect all tanks for security and leaks.

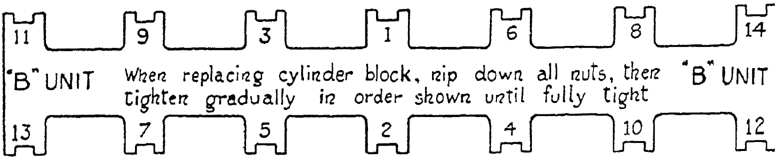


Fig. 5.—ORDER FOR TIGHTENING CYLINDER HOLDING DOWN NUTS.

Check the specific gravity of the cooling liquid if anti-freezing mixture is used.

Inspect all pipe lines for security and soundness.

Inspect all cocks for stiffness.

Inspect all bonding and screening.

Remove airscrew hub and inspect shaft for wear on splines and end float.

Test all cylinders and investigate if compression is not correct.

Inspect all vent pipes.

Test all controls for setting and adjust if necessary.

After 120 Hours' Flying

Fuel, Lubrication and Cooling Systems

Complete systems to be emptied and tanks flushed out.

Inspect for corrosive action.

Cylinder Holding Down Nuts

Check for tightness, using the special clutch spanner provided with a pre-determined slip, and in the order as shown in Fig. 5.

To do this the camshaft and rocker mechanisms must be removed. When replacing this unit it is necessary temporarily to secure the rockers as shown in Fig. 4, by using a soft wire A fixed to one end of bracket B and threaded under the rockers.

If the bevelled gears are suitably marked re-timing will be unnecessary.

Sparking Plugs

A new set of sparking plugs should be fitted.

After 480 Hours' Flying

Remove the engine for complete overhaul, as described in a separate article.

Notes for High Temperature Climates

Wear on pistons, piston rings and bores of liners is likely to be more on account of abrasive action of dust or sand in suspension generally in such climates. This will be revealed in loss of compression and corre-

sponding loss of power with difficult starting as the flying hours increase. When the lubricating oil is changed and the sludge analysed the amount of sand and dust together with the extent of compression loss will form indications as to the advisability of changing the cylinder blocks before the engine is removed for complete overhaul. In extreme cases it may be advisable to change the cylinder blocks after 240 hours, *i.e.*, one life of an engine before complete overhaul necessitates two sets of cylinder blocks. These are changed simply as assemblies with the necessary attention to pistons and piston rings at the time of changing.

Inspect all rubber connections for serviceability after twenty hours instead of forty.

AIRFRAME AND ENGINE MAINTENANCE AND OVERHAUL

THE IMPERIAL AIRWAYS SYSTEM

By J. H. Robson, *Operating Manager, European Division, Imperial Airways*

THE commercial aeroplane—essentially a high-performance transport vehicle—depends largely in its routine operation on a specially organised system of maintenance and overhaul, but, before giving an outline of this system, it is advisable to deal firstly with the various stages of its development and secondly with the organisation which has been found necessary to ensure its successful application.

It may be recalled that the first aeroplanes used commercially after the Great War were military types converted so as to enable them to carry passengers. But having been designed and constructed for war purposes without regard for such operational and maintenance problems as would arise in civil flying, their employment on pioneer air lines was confined to a transitional period during which designs were being prepared incorporating the essentials of the commercial aeroplane.

Any examination of the early development of aeroplanes as transport vehicles soon reveals a salient point.

So much of the time of these aeroplanes was spent in the hands of fitters and riggers that it was possible to make only a very limited use of them for the carriage of commercial loads.

This was largely due to the fact that, in those days, systematic methods of maintenance and overhaul had not developed to the stage they have reached to-day.

Different people had different ideas, and work was carried out at the discretion of the individual, largely because of their different experience and in the absence of accumulated records of systematic operation.

This fact, and the fact also that aeroplanes used on early air services were ill-adapted, structurally, for routine commercial maintenance, meant that an altogether disproportionate amount of time was spent in the hangars in adjusting the rigging and engines and in getting them into satisfactory flying trim.

Pioneer Days of Air Transport

Those were the days, of course, in which pioneer air transport was buying its experience in the hard school of trial and error.

As soon as the first purely tentative phase had passed, and endeavours

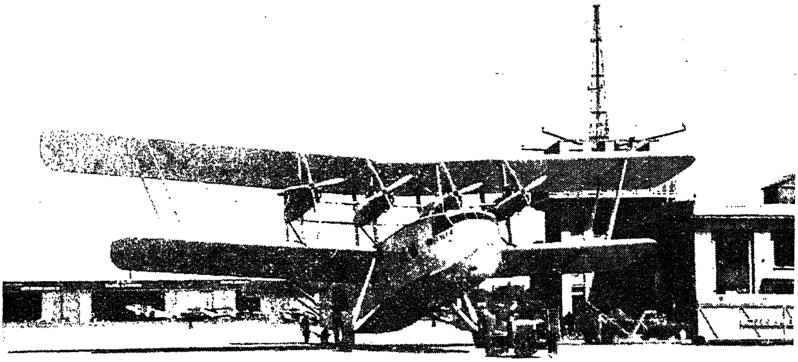


Fig. 1.—TOWING IN AN AIR LINER FOR INSPECTION AFTER A FLIGHT.

The above photograph shows the Imperial Airways Air Liner "Scylla." Note the Croydon Control Tower and wireless mast in the background. We are indebted to Imperial Airways Ltd. for facilities for staging the accompanying series of photographs showing various operations in the between-flight inspection of air liners.

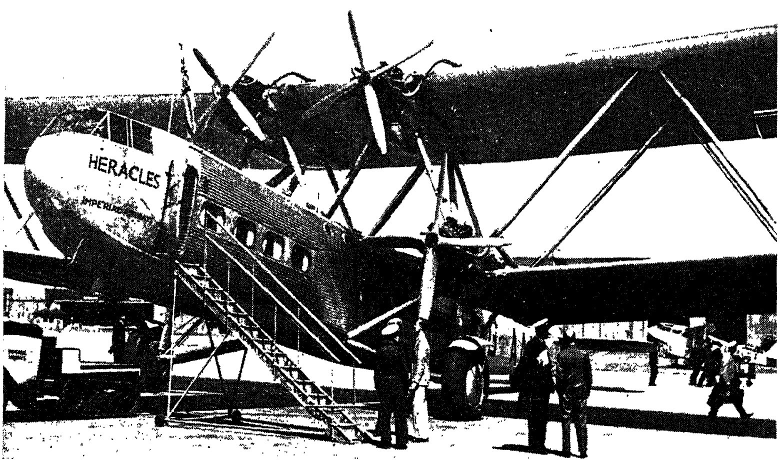


Fig. 2.—THREE-QUARTER FRONT VIEW OF "HERACLES" ON THE TARMAC OUTSIDE THE CROYDON CONTROL TOWER.

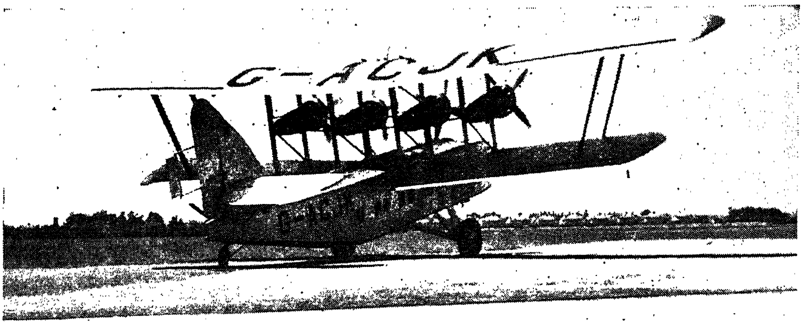


Fig. 3.—THE " SYRINX " AIR LINER MOVING INTO POSITION.

The view below shows the flying controls in this modern Imperial Airways air liner.

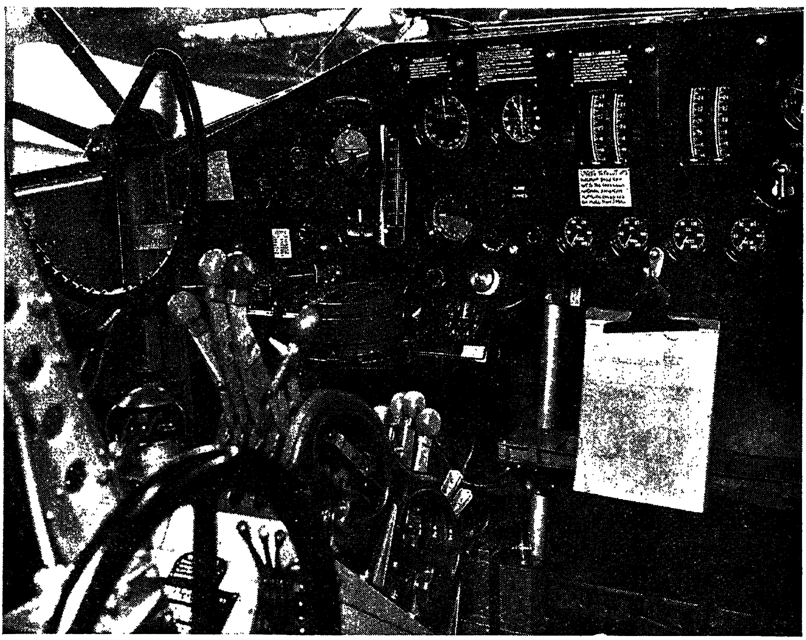


Fig. 4.—THE PILOT'S SEAT IN THE 'SYRINX.'

The control column which has superseded the " joy stick " is shown on the extreme left. The wheel in the bottom left foreground is the tail-trimming device. Between the two can be seen the throttle and mixture controls. The compass is mounted horizontally in the centre of the picture. The pilot notes any incidents in engine running or flying on his voyage report, which can be seen on the right of the picture.

were being made to adapt to air transport some of the fundamental principles governing other forms of transport, it was realised that, if anything like normal commercial operation was to be achieved, methods must be devised for a more intensive system of flying, in which far more time was spent actually in the air and far less time in the hangars. Assuming that an aeroplane had only a certain given period during which it was a potentially useful transport vehicle, and assuming that a large proportion of that time was spent unproductively in the sheds, then the goal of normal, profitable operation seemed very far off indeed.

It was at this stage that the experience of the operators of other systems of transport was adapted and applied to air transport and special methods of maintenance and overhaul were developed to meet the specific needs of commercial aviation. The development of such methods was aided by the fact that, from the earliest days of civil aviation, the operation of regular air-lines had been providing a constant testing-out process for aeroplanes under definitely commercial conditions.

How Operating Efficiency has been Obtained

This meant that, apart from any fundamental issues arising in design, those engaged in maintenance and overhaul were, as each successive type came under discussion, able to suggest improvements in constructional details which would facilitate maintenance.

In this way, one had a dual process at work. Aeroplanes were gradually being made more suitable for commercial operation, whilst actual experience in operation was enabling constantly improving systems of maintenance to be employed. The goal always in view was, of course, to obtain the greatest amount of actual flying from every unit of a fleet and also to ensure for each unit the highest possible degree of operating efficiency.

Imperial Airways System

The air routes of Imperial Airways, European and Empire, are divided for operating purposes into a series of divisions. The headquarters of the European Division, for example, is at the London Airport, Croydon, and those of other Divisions at convenient centres along the main Empire routes.

The Chief Engineer of the Company has his headquarters in the London Office at Airway Terminus, Victoria. Under his guidance are the engineering departments of all operating divisions, European and Empire, and in each division there is an Operations Manager. The operating and piloting of the aeroplanes in his division, and also the work of the Engineering Department under its Engineering Superintendent, come under the supervision of the Operations Manager. In actual practice it is found advantageous to have an Operations Manager acting as a direct link between the flying and handling of the aeroplanes and the maintenance and overhaul work of the Engineering Department.

In the Imperial Airways system any potential disadvantage of divided control is eliminated. It may happen, for example, that the flying personnel find they want to lay stress upon some specific point concerning the handling of a particular unit of the fleet. In every Division, they are perfectly at liberty to talk over the matter with the Operations Manager, and then if necessary the Operations Manager discusses the matter with the Engineer Superintendent, suggesting perhaps that particular attention should be paid to some detail arising during the routine maintenance work. Conversely, the Engineer Superintendent has the opportunity of bringing to the notice of the Operations Manager any aspects of individual pilotage which he considers might tend to complicate the work of the Engineering Department. Thus the unified method of control smooths away difficulties and increases efficiency.

The Company's Air Superintendent, himself a pilot of long and extensive experience, has his office in the London Headquarters, and is at the head of all the Company's staff of pilots, European and Empire ; any matter affecting pilotage that cannot be dealt with divisionally is, of course, referred to him for his consideration and decision. In the same way any engineering problem, on which divisional engineers require advice, is referred to the Chief Engineer in London.

Flexibility and Team Work

These points provide illustrations of the Company's policy of organising each department as a self-contained unit, and yet providing a system sufficiently flexible to enable departments to assist and collaborate with each other. This prevents costly and vexatious delays and permits an unhampered efficiency in all directions. A main factor in the success of any transport organisation, whether it operates on land, sea or in the air, is really effective inter-working between various departments. It is, for example, the task of the traffic and sales departments to obtain the necessary loads. It is the task of the Air Department to provide qualified and experienced captains and crews to navigate the aeroplanes, and it is the task of the Engineering Department to see that all the aeroplanes employed are in a state of high operating efficiency. It is the duty of all departments to discuss mutual problems and to indicate improvements suggested by their particular experience.

The London Airport

Having cleared the ground to this extent, it is now possible to enter more into detail ; for example, a specific section of operating activities—that of the European Division of Imperial Airways at the London Airport, Croydon.

At Croydon are the big hangars in which the air-liners are housed and where they are worked upon and maintained between flights ; also the hangars into which aeroplanes are taken for more detailed periodical

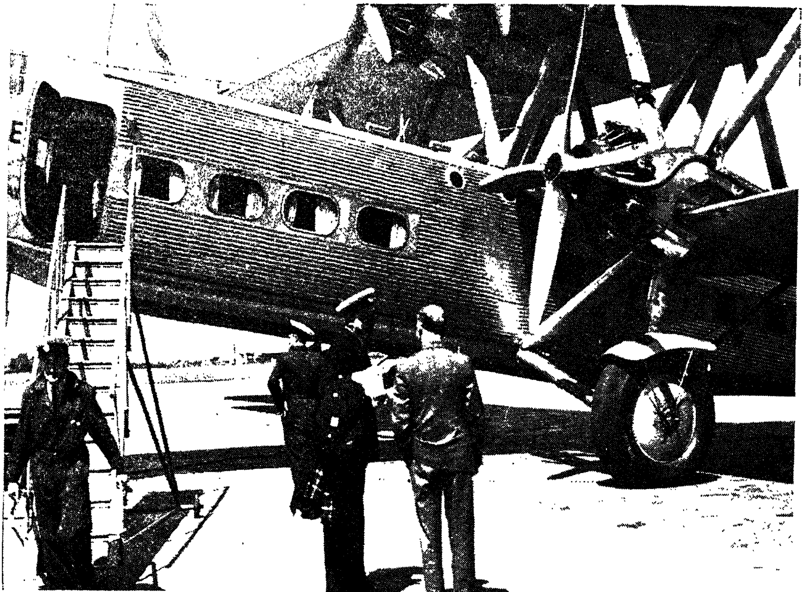


Fig. 5.—THE COMPLETION OF A FLIGHT (1).
The pilot has a word with the engineer superintendent regarding the aircraft's performance.

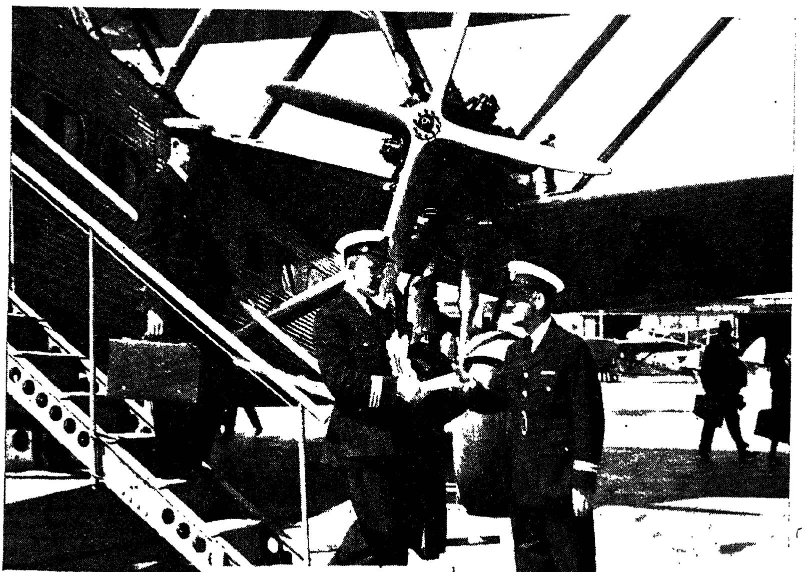


Fig. 6.—THE COMPLETION OF A FLIGHT (2).
s over the daily log-book to the ground engineers' foreman to be completed
ion which follows after flight.

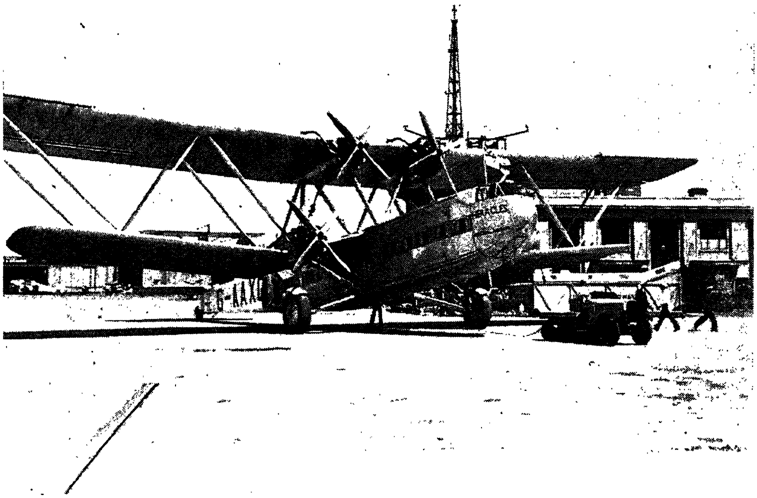


Fig. 7.—" HERACLES " BEING TOWED IN TOWARDS THE HANGARS AFTER A FLIGHT TO UNDERGO ITS REFUELLING AND ROUTINE INSPECTION.

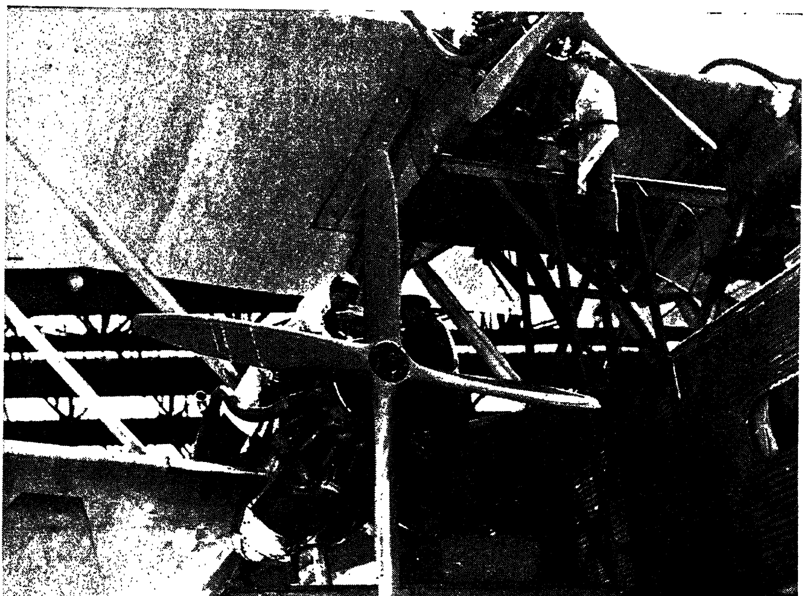


Fig. 8.—INSPECTION IS THE KEYWORD OF SAFETY IN THE AIR.
Every time a machine comes in after a flight it is submitted to rigid and expert scrutiny.

overhauls, and the workshops which deal with engines and other airframe parts. The general engineering equipment, as it exists at Croydon, is duplicated at various overseas bases where the maintenance and overhaul of aeroplanes is undertaken. Methods of maintenance and overhaul, as undertaken at Empire stations, may be varied or modified in detail, according to climatic and other conditions. There is also, of course, a special technique necessary in the maintenance and overhaul of commercial flying-boats.

Maintenance Routine

Now suppose we take some illustrations of how the system of maintenance actually functions under normal operating conditions. In order to have a concrete example, let us take the arrival at Croydon one evening of an Imperial Airways air-liner which has just completed a flight from some point on the Continent.

Awaiting the aeroplane, as it lands and taxies up to the main buildings, are the members of the Running Shift. These are the men of the maintenance staff who take charge of incoming and outgoing aeroplanes while they are being towed by tractors to and from the hangars, and who also give the airframe and engines a routine or refuelling inspection while they are being "turned round" after alighting at Croydon, preparatory to taking off again on another scheduled flight.

In the case we are considering, the aeroplane has finished its day's work, and so, in the charge of the Running Shift, it will be towed round by a tractor to the main hangars, but, preparatory to this, we come to one important detail of the system. This will be the handing over by the airliner's Captain to the foreman of the Running Shift the "Daily Report," dealing with the operation of this particular aeroplane.

It is an essential aspect of the maintenance and overhaul system that, in addition to all the routine work of the ground staff, steps are taken to make certain that the fullest possible information is available from those actually handling the air-liner—that is to say, from the pilot flying it on its daily trips.

The Captain's Report

Space is therefore provided in the "Daily Report" carried by the air-liner for a complete record by each Captain of all essential details regarding the behaviour of his aeroplane while in flight and of the functioning of the engines driving it. The Captain, for example, reports on the way in which the aeroplane responds to its controls, noting any deviation, even the slightest, from normal flying trim. Should there be even the smallest tendency for it to be nose or tail heavy, this will be duly entered up in his report, in order that it may receive the immediate attention of the Engineering Department. In the same way the Captain will record any tendency for the aeroplane to fly with port or starboard

wing a trifle low. Such details as these, while of course in no way effecting the general controllability or handling of the aeroplane, are just the sort of details that the Engineering Department require in order that each necessary adjustment—as indicated by the Captain's report—can be carried out by the engineers of the maintenance shift.

This report by the Captain, signed by him on alighting, together with the records of the self-recording instruments that are carried, give the Engineering Department the necessary information about this particular air-liner's performance during its day's flying. No detail is omitted. Nothing is left to chance. These daily reports and records give a complete history of the handling and mechanical efficiency of every unit of the Company's fleet that is in flying service.

Instruments

In addition to reporting on the general flying trim of his aeroplane, the Captain has a good many other details to note in his " Daily Report." He is called upon for notes as to the functioning of his various instruments. Does the compass behave as it should ? Is the air-speed indicator functioning normally ? Is the low-reading altimeter satisfactory ?

There are other instruments, too, each requiring a note in the " Report " as to the way in which it is continuing to do its work—instruments such as the rate of climb indicator, the turn indicator, the artificial horizon and the directional gyro. The Captain is required to report on such details as the functioning of his fuel-contents gauge and the rate at which the generator is charging. He also makes a note as to the operation of the undercarriage and wheel brakes.

All this essential data has to be compiled in respect of each trip an air-liner makes during its day's work. On a flight out from London to the Continent, for example, it may be scheduled to land several times before it reaches the airport on the Continent which is its terminal point. There it will re-fuel and be made ready for its return to Croydon ; and for each of these flights, outward and homeward, space is provided in the " Daily Report " for the Captain or First Officer to enter the notes required as to the behaviour of the aeroplane and its instruments.

It should be mentioned here that at the airports on the Continent, to and from which the Company's air liners fly regularly, the Company has its own maintenance staffs, operating according to the same general system that prevails at the main station at Croydon. Details of inspection work carried out while air-liners are on the ground at continental ports, and details also as to re-fuelling operations, appear in the " Daily Report " carried by the air-liners and are available immediately the aeroplane returns to Croydon.

Engine Behaviour

In addition to the information he provides regarding his aeroplane

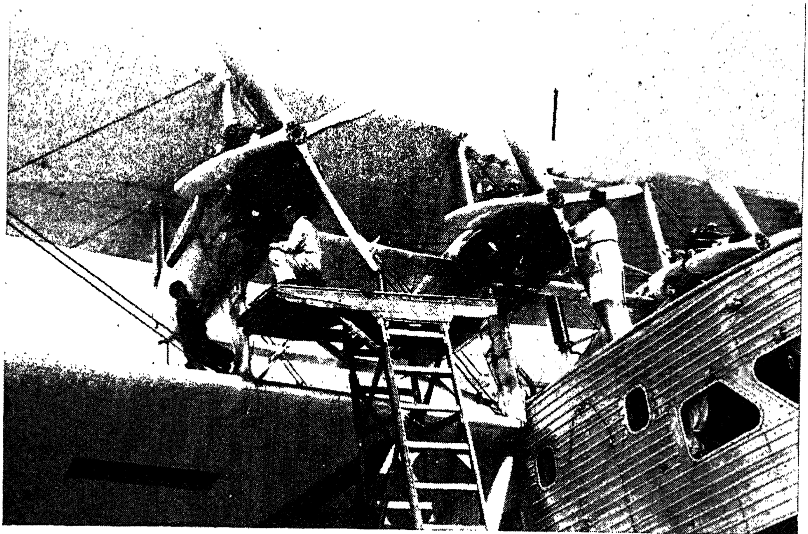


Fig. 9.—Two routine operations in a between-flight inspection.

Showing on the right checking the airscrew for tightness, and on the left examining a faulty sparking plug.

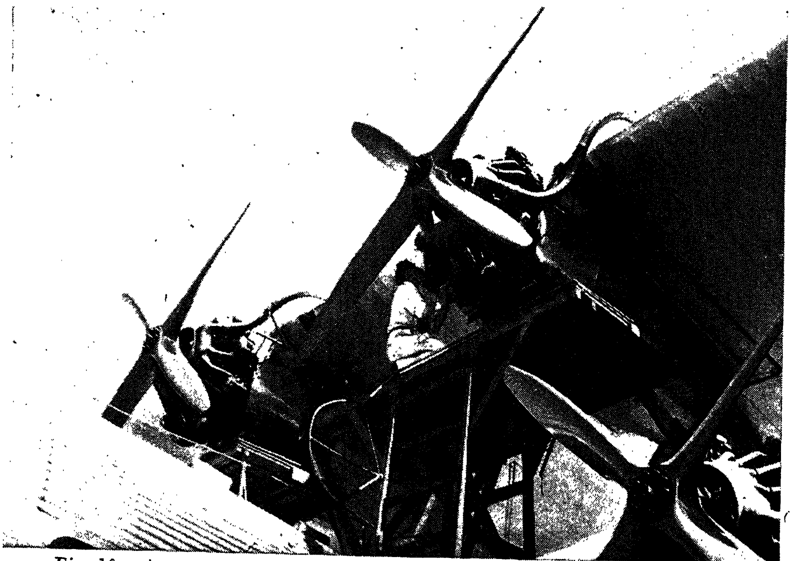


Fig. 10.—A stage in the inspection of the engines after a flight.

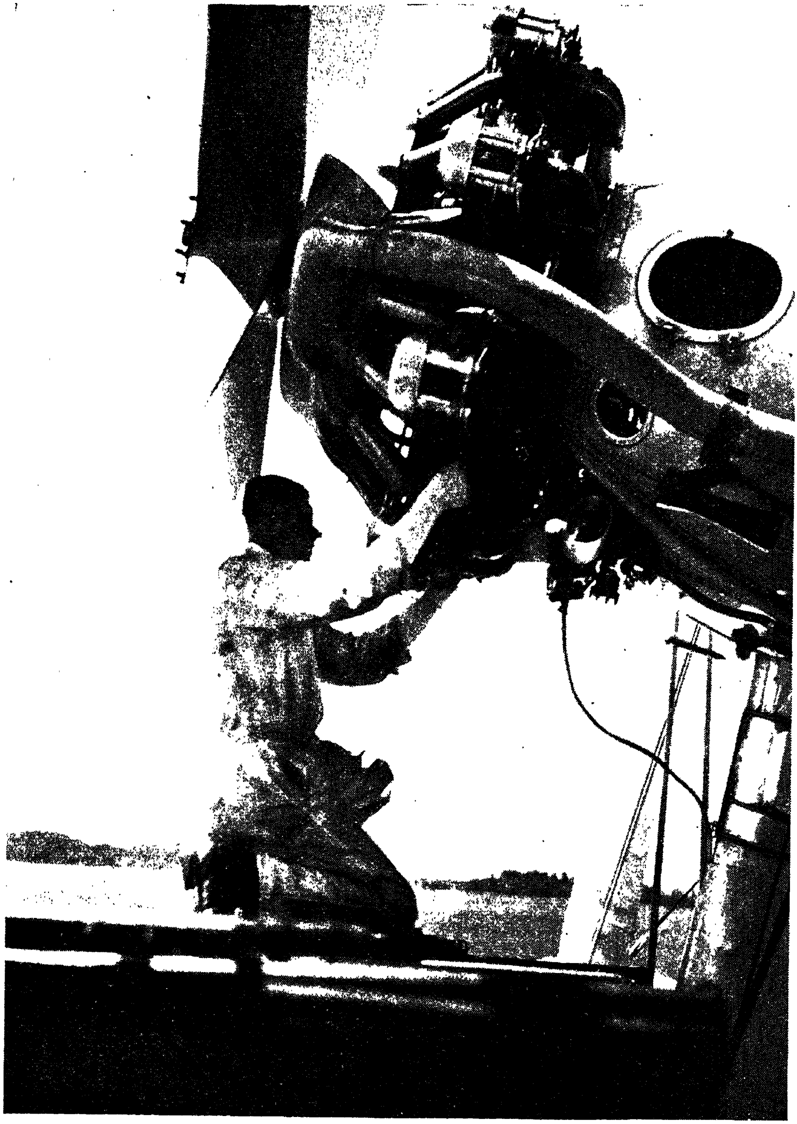


Fig. 11.—ALL SPARKING PLUGS ARE CHECKED FOR TIGHTNESS DURING A BETWEEN-FLIGHT INSPECTION.

This is invariably carried out as a safety precaution before the air liner takes off again. The engine shown is one of the Jupiter X F.B.M.'s mounted on *Scylla*.

and the functioning of his instruments, the Captain is called upon for a detailed report as to the operation of the engines. For each of the four engines in the Imperial Airways multi-motored power-plants special entries are required—port outer engine, port inner engine, starboard outer engine and starboard inner engine.

In regard to the operation of an air-liner's engines, there are many things the Engineering Department want the Captain to tell them. They want to know, first of all, that each engine is running in a generally satisfactory manner. They want to know that the fuel system is operating satisfactorily. They want to know whether the slow-running revolutions per minute are satisfactory when the aeroplane is on the ground, and also the full-throttle revolutions per minute obtained when the engines are opened up for the take-off. Details are also needed as to full-throttle revolutions per minute of the engines when the air-liner is in the air and in addition the revolutions maintained when the air-liner has gained her required altitude and is proceeding at normal cruising speed. Notes are also needed on such points as oil temperature and pressure and the pressure given by the " boost " or super-charging mechanism. Should there be any vibration observed on any engine the Captain will, of course, report this, noting the revolutions per minute at which it occurs.

Wireless Equipment

In addition to the accurate functioning of the aeroplane and of its engines and instruments, as indicated by the entries made by the Captain, there is another essential feature of the equipment of a modern air-liner, and this is its wireless installation. In the " Daily Reports," therefore, a special page is reserved for the information that is required from the wireless operator.

For each of the daily journeys an air-liner may be making, the wireless operator is provided with space in his " Report " for comments on the functioning of the transmitter and receiver. He also makes any notes necessary as to the operation of the homing device and the general functioning of the power plant. He makes an entry of all signals transmitted and received in the appropriate log book.

To return to the specific point in the routine when an air-liner has alighted in the evening at Croydon after its day's flying. The " Daily Report " which has been described will have been handed by the pilot to the foreman of the Running Shift and the next stage will be the towing of the aeroplane by a tractor to the main hangars. The Captain and his crew have now finished with the aeroplane temporarily. It is back in the hands of the Engineering Department and it is their task to prepare it for its next day's work.

The Inspection Department

As soon as an air-liner has been manœuvred into the hangar and is in

position ready for the work of the maintenance staff, it comes into the hands of the Inspection Department. The work of these inspectors—each being licensed officially by the Air Ministry for his particular task—represents a vital aspect in the efficiency of the maintenance and overhaul system. It is the inspector, after making his expert examination of any air-liner which has just come off service, who indicates any special job that he considers should be done, over and above the specified items of regular maintenance. It is the inspector, also, who looks over all that has been done on an aeroplane before the work can be approved officially.

To assist him in the examination which he makes of the air-liner, the inspector has the Captain's report on the day's flying as embodied in the "Daily Report." All these notes, as to the recent functioning of the aeroplane, the inspector studies. Also, he makes his own notes and observations. For these notes by the inspector special pages are provided in the "Daily Report," following upon the entries made by the Captain and the wireless operator.

The Ground Engineers

The inspector, after he has examined the aeroplane, enters in the "Daily Report" the items of work that he considers require attention. An individual number is given to each item and then the "Daily Report"—now containing the notes of the Inspector as well as those of the Captain—passes into the hands of the foreman or ground engineer who will be in charge of the men actually working on the aeroplane.

It should be mentioned here that the maintenance work on air-liners is conducted on a twenty-four hours' basis, a night shift succeeding the two day shifts and the whole work proceeding continuously. Thus an air-liner which has come in during the evening, and which has been duly examined by inspectors, will pass into the hands of the night maintenance shift, who will work on it with the object of preparing it for service on the following morning.

It should also be mentioned at this point that the work of the inspector who examines the aeroplane and its equipment is repeated in respect of each engine and its installation. Here, again, special pages are provided in the "Daily Report" for an inspector to make his notes as to any items of work on the engines which require the attention of the ground engineers. Each engine of a power plant of four engines has its particular page for this purpose. Items of work are numbered and the ground engineer duly enters up each item and signs at an indicated spot to show that the work called for has been properly carried out.

General Routine

Apart, of course, from any specific point to which attention has been called by the Captain of the air-liner in his report, or any particular item of work required by an inspector after his examination of airframe or

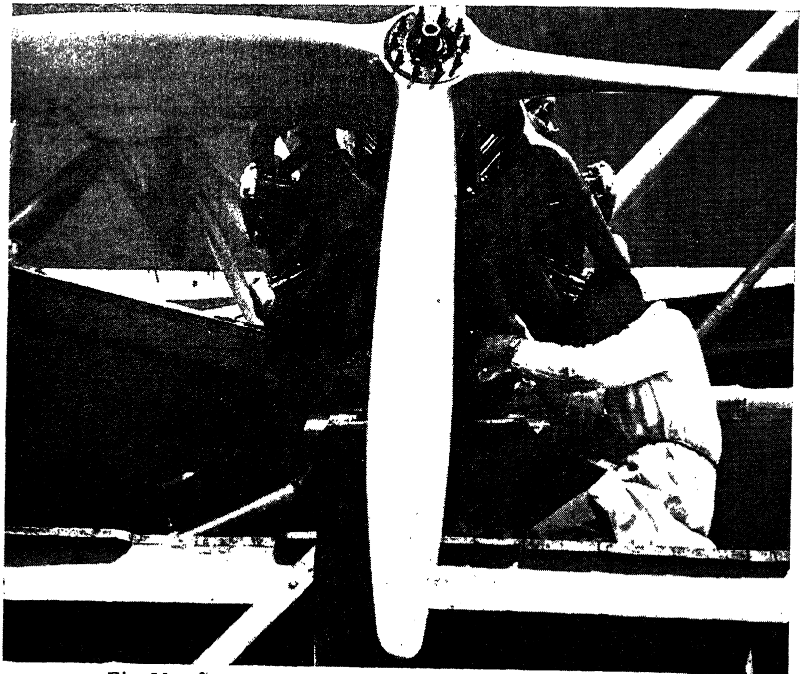


Fig. 12.—CHECKING THE PUSH RODS FOR EXCESSIVE CLEARANCE

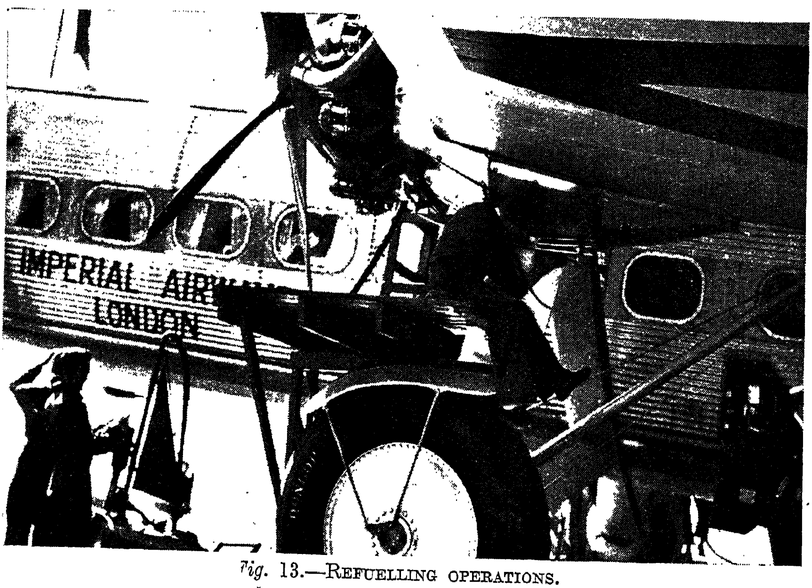


Fig. 13.—REFUELLING OPERATIONS.

engines, there is a general routine carried out in each case by the maintenance staff. This routine is usually compiled in collaboration with the manufacturers of the airframe and engines, but continuous experience of a type enables the operator to amend the routine programme from time to time so as to provide all the necessary attention at the lowest possible labour cost.

Airframe

As regards the airframe, there is, for example, a general greasing routine. Undercarriage fittings and wheels are greased. Controls are cleaned and lubricated. There is also a routine examination of the electrical system. In addition, all control surfaces are examined to make certain that their condition is satisfactory, and all attachments tested to make sure that they are secure. The pitot-heads of the air-speed indicators are cleaned and checked for leaks.

Engines

As regards engines, maintenance routine includes, among other things, such items as "cylinder compressions checked," "fuel filters cleaned," "oil filters checked and cleaned," "valve clearances checked and adjusted," "sparking plugs checked," "magnetos examined," "contact-breakers cleaned" and airscrews changed or refitted as required.

Final Inspection

All this work that has been proceeding during the night is on the following morning the subject of another examination by inspectors. They now have a complete record of everything before their eyes. Each item that has arisen duly figures in the reports. The Captain—just to take a definite instance—may have made some specific reference to one of the instruments in his cockpit. This will have been noted by an inspector when the air-liner came into the hangar in the evening. And now, after the work of the night shift, the engineer responsible will have listed this particular item as having been dealt with and will have signed the report to that effect. The inspector, in his final check up on the whole process, will himself examine this item, among others, and satisfy himself that everything is now in order. The same applies to any point concerning any particular engine in the air-liner's power plant. It may be a note from the pilot, calling attention to some necessary adjustment in connection with one of the revolution indicators. This matter will have gone through all the indicated processes, and now the inspector, in his final examination, will check up on this individual item and so make doubly sure that nothing has been overlooked.

Specific points have been mentioned in order to provide illustrations of how the system works in each of its stages. The aim, so far as is humanly possible, is to eliminate any risk of a small trouble arising which might in

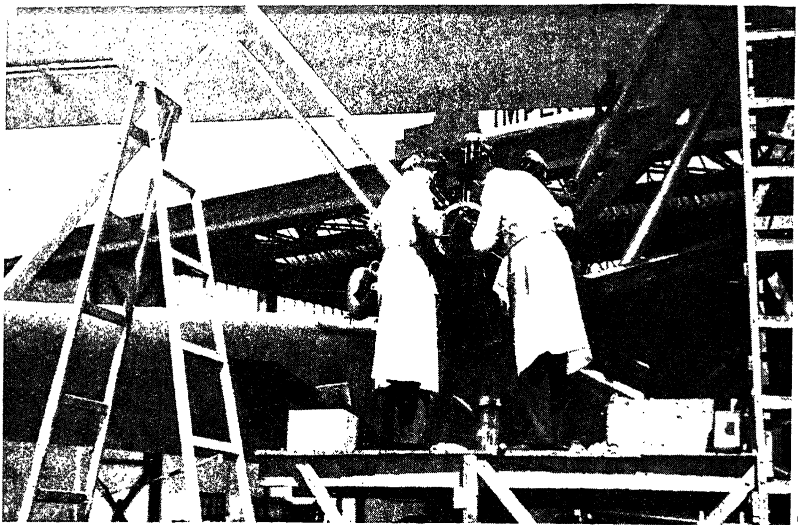


Fig. 14.—A MAJOR OPERATION IN PROGRESS.

Note that the airscrew and exhaust manifold have been removed. This is sometimes necessary in order to repair small cracks which appear in the manifold through vibration and heat distortion.

Fig. 15.—EXAMINING THE AUXILIARY TWO-STROKE STARTER MOTOR.

This motor pumps mixture into the engine cylinders and turns the airscrews round slowly. When the engines have started by coil ignition this motor is shut off.

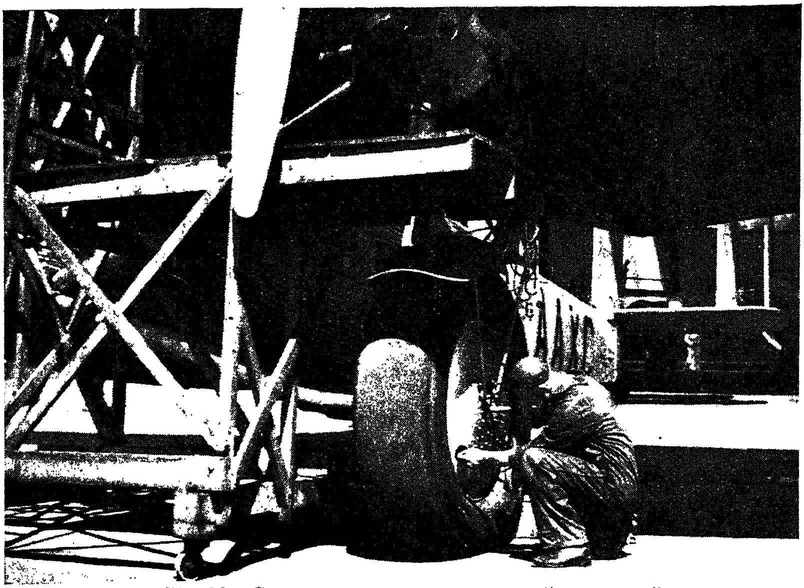


Fig. 16.—CHECKING TYRE PRESSURES ON "HERACLES."
In the foreground can be seen the rostrums on which the ground engineers stand when inspecting the engines.

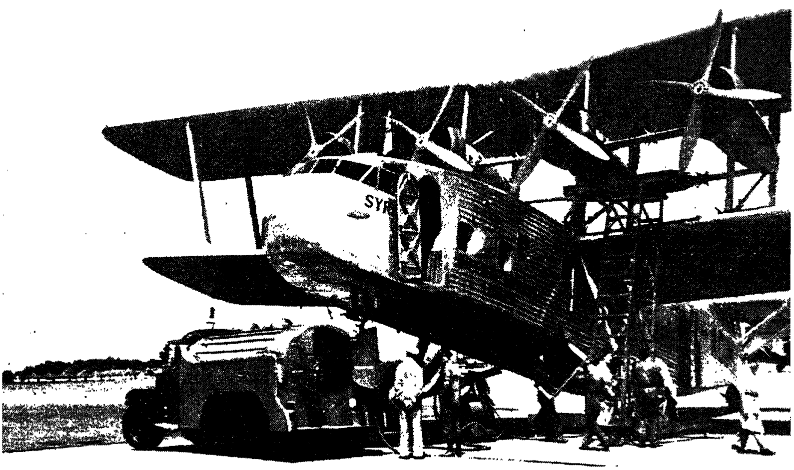


Fig. 17.—THE MOBILE REFUELLING PLANT READY TO BE CONNECTED UP TO THE TANKS IN THE CENTRE SECTION OF THE TOP WING.

time, if it were not dealt with, lead to something more serious in the way of mechanical failure. As it is, in the first place the crews watch the behaviour of air-liners while they are actually in flight. Their observations are reinforced by the frequent expert examinations of officially certified inspectors. Each item of work is numbered, entered up and duly carried out, the engineer who has done the work signing and vouching for each item. Finally we have another careful examination by the inspectors.

The Certificate of Airworthiness

Now to come to one of the fundamental features of the whole of the safety system in regard to the operation of commercial aeroplanes. This is the granting to an air-liner of its daily certificate of safety for flight. Without this certificate, signed by one of the ground engineers specially licensed by the Air Ministry, it would not be permissible under the regulations for any aeroplane to leave the ground on a scheduled flight carrying a commercial load. Before the ground engineer signs this daily certificate he will, as already mentioned, possess documentary evidence and have the opportunities of satisfying himself that every item of maintenance has been carried out and every detail of the aeroplane is in perfect working order.

Then, and not till then, will he sign the certificate to the effect that the aeroplane is " safe in every way for flight." It should be mentioned that the certificate also contains a special signed declaration in connection with the engines, these being " run up " and vouched for by a licensed ground engineer in the words that he is " satisfied that they are in every way fit for flight."

These certificates, signed by the ground engineer in the morning before the air-liner departs, are, it should be mentioned, intended to cover the operation of the aeroplane during the ensuing period of twenty-four hours. When the air-liner has finished its day's flying, and comes back into the hangar for another spell of routine maintenance, it will require a fresh certificate on the following morning before it can resume flying.

This illustrates the constant, unbroken nature of the supervision that is employed ; every day, after an aeroplane has completed its scheduled flying, it is subject to a routine process of maintenance by the engineering staff, and each morning, before it goes back into the hands of the pilot, it needs to have a new daily certificate of airworthiness.

It is satisfactory to note that it has now become a very rare thing indeed for an Imperial Airways flight to be delayed or cancelled through anything in the nature of mechanical trouble.

The Twenty-five-hour Overhaul

The account given of the daily and nightly routine of the Engineering Department does not, by the way, tell the entire story. This daily

routine is merely a part of the general system which has been evolved. For example, after it has been in the air for a period of twenty-five hours, each of the air-liners is subjected to another and a fuller process of examination in addition to its normal maintenance. Everything is inspected in detail at this twenty-five-hour overhaul—airframe, engines, engine installations, airscrews, instruments, controls and control gear and undercarriage. This fuller examination every twenty-five hours is intended to deal with points that do not need daily attention and which would merely involve waste of time to examine at more frequent intervals. Finally comes the annual overhaul which each aeroplane undergoes and which is essential before it can be granted a fresh " airworthy " certificate covering another twelve months of operation.

The Annual Overhaul

For its annual overhaul the air-liner comes off service and goes into a big shed reserved for such overhaul work. Everything is now stripped right down. Engines are removed, planes are taken off for detailed and internal examination and undercarriages dismantled. The entire airframe is subjected to a close and detailed inspection. Replacements are carried out in every case where they appear necessary. Before a new certificate of airworthiness is granted, covering a further period of twelve months, the air-liner has been overhauled to the smallest detail and every part of its structure is restored to a condition of complete operating efficiency.

With the increase in size of aeroplanes, the annual overhaul is sometimes not all done at one time, but various main units are overhauled in rotation during the year. By this means the aeroplane will not be off service continuously for the same long period as if the whole annual overhaul were done at one time. However, every part of the aeroplane undergoes the complete annual overhaul routine once within every twelve months.

Engine Overhaul, Every 600 Hours

A special note needs to be made here as to the routine with engines. The method in the case of power plants is to reinforce the normal routine with a complete overhaul of each engine after it has completed 600 hours of operation. It is then removed from the structure, taken into the engine shop and completely stripped. Every part is inspected and checked for wear, replacements being made as required. The engine is cleaned and generally re-conditioned and is subjected to special tests before it goes back again into service. Among the apparatus employed in the engine shops during these overhauls may be mentioned a special device for detecting minute flaws or cracks in any ferrous engine components. What this apparatus does, first of all, is to magnetise any steel part that is to be examined, then a liquid called " detecting ink " is

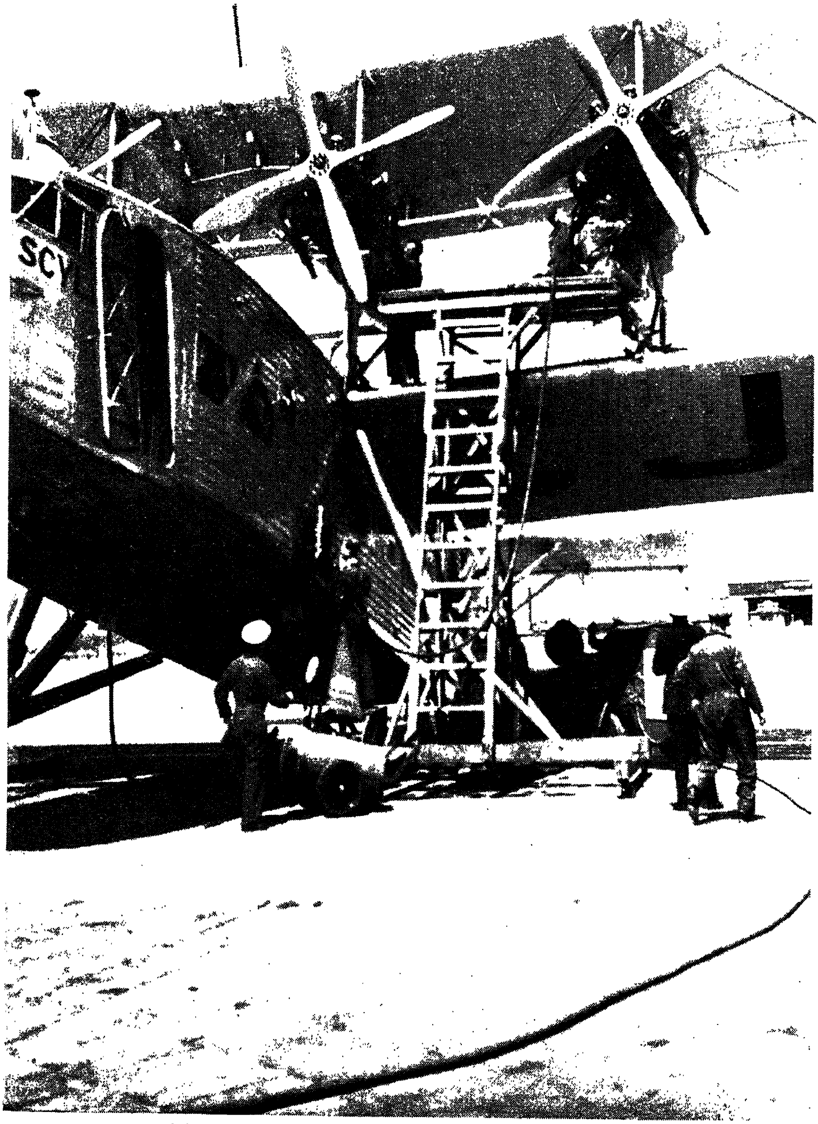


Fig. 18.—REFUELLING OPERATIONS ON "SCYLLA."

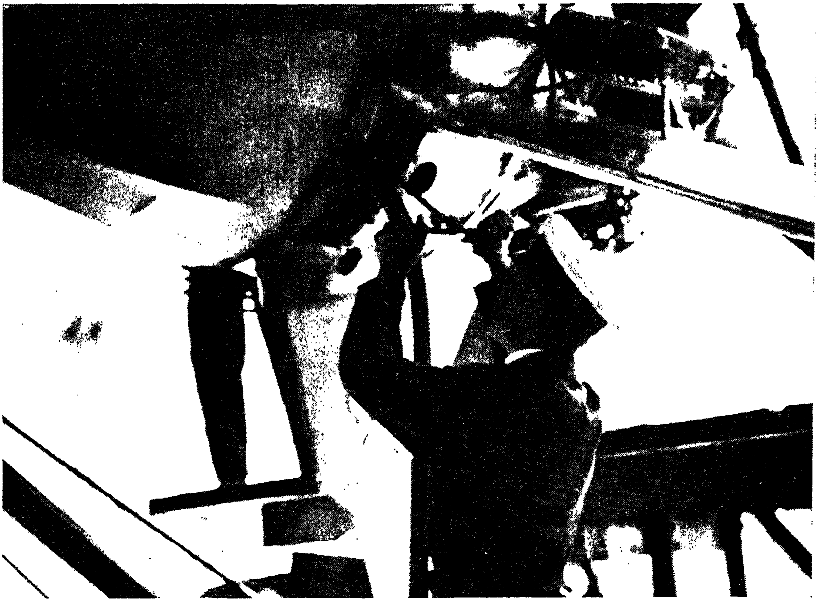


Fig. 19.—FIXING REFUELLING PIPE INTO LOWER ENGINE NACELLE.

Fuel is pumped thus into the top wing at the rate of 30 gallons per minute by an electrically-driven power pump.

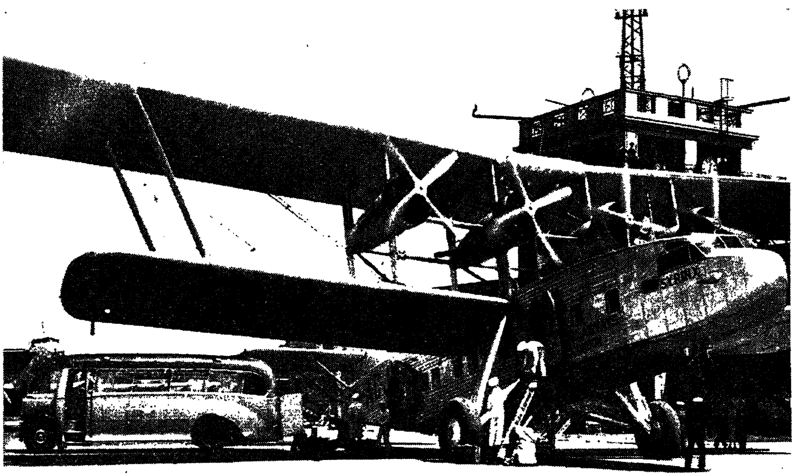


Fig. 20.—READY FOR FLIGHT AFTER INSPECTION AND REFUELLING.

This shows the air liner "Syrinx" being loaded with passenger luggage. Both passengers and luggage are weighed to ensure that the air liner is not overloaded.

poured over it. This liquid has the property of evaporating very slowly, while contained in it is a specially prepared metallic powder. When the liquid is poured over a magnetised part it has the effect of revealing on the steel surface of the part, in the shape of a thin, black, tell-tale line, any tiny surface crack or flaw, which might have remained undetected except for the use of this special magnetic process. Crankshafts, airscrew shafts, wheels, gears, oil-pump drives—all such parts as these, and others too numerous to mention, are subjected to this particular process.

The Stores Department

A point that need hardly be emphasised is that an essential feature of the organisation is the efficient planning and maintenance of a fully equipped Stores Department. To cope with airframe and engine maintenance on a large scale requires a most extensive and carefully arranged stores system. Large and varied are the stocks of spares necessary for airframe and engine replacements, and not only is it necessary to legislate for replacements on the European or home division, but there are also the various Empire or overseas divisions to keep well supplied with everything that they may need in the way of spares.

The system is arranged so as to simplify in every way possible the requisitioning and supplying of any item, whether large or small. Code numbers are employed to identify particular parts, while the internal equipment in the main stores embodies a system of stocking parts which is devised specially to meet particular requirements and which enables any and every item to be readily accessible.

Naturally the aim is to take every step possible to keep within reasonable bounds the number of spares. At one early stage in the development of the Imperial Airways organisation the Company was employing not only a miscellaneous fleet of aeroplanes of various types, but also a number of engines of different types, air-cooled and liquid-cooled. This, of course, complicated the problem of spares. Gradually, however, as opportunities have arisen, the policy has been to reduce, as far as conditions permitted, the number of different types of aeroplanes employed and also to standardise power plants of air-cooled types. This policy—and more particularly the policy of concentrating on air-cooled engines—has helped very much in limiting and simplifying the difficulties and problems of the stores department.

Progress Through Co-operation

For nearly fifteen years there has been continuous operation by Imperial Airways, while it is now nearly twenty years since the first commercial air services were established between London and the Continent. Those are very short periods when regarded from the viewpoint of the development of any new method of transport. But, all the same, they have seen remarkable progress in every phase of air transport.

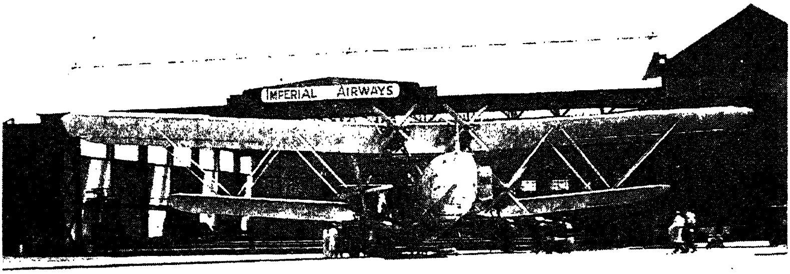


Fig. 21.—"HERACLES" OUTSIDE THE HANGARS.

They have seen the commercial aeroplane, year by year, become a far more satisfactory structure from an engineering standpoint: it has become more robust but at the same time more complex in construction, while providing steadily improving pay load factors. Part for part, it has also become far easier to maintain and overhaul, troublesome details having been eliminated in the light of operating experience, but the greater complexity, efficiency and size of the modern aeroplane still leave plenty of maintenance problems. This process continues steadily. There is close co-operation between those who employ and maintain commercial aeroplanes and those who design and build them. And such a co-operation, in view of the increasing complexity of the modern aeroplane, is all-important in operating, maintaining and overhauling a constantly growing fleet of air transport vehicles, to meet ever-increasing demands for higher speeds, greater ranges, still better regularity and lower costs.

THE DE HAVILLAND LEOPARD MOTH

(TYPE D.H. 85)

By A. J. Brant, *Service Manager, de Havilland Aircraft Ltd.*

THE Leopard Moth has been expressly designed to convey two, or occasionally three, persons over long distances at high speed, with comfort and economy, and possesses an amply large load-carrying capacity for all practical purposes.

Although, due to strength factors above the normal for an aeroplane of this class, it is fully capable of performing the usual aerobatics, it should be looked upon primarily as a vehicle for serious and extensive travel, for which duty are incorporated its many refinements and fittings, all tending towards physical comfort.

The Leopard Moth has a wide range of speed from 141·5 m.p.h. high speed to 45·5 m.p.h. low speed with normal load. Its cruising speed is high compared with most civil aeroplanes, ranging between approximate high and low limits of 125 m.p.h. and 95 m.p.h., a reasonable average under normal conditions being 105 to 115 m.p.h. A low cruising speed naturally results in less wear and tear on the engine and a low fuel consumption; but, against a head wind, it is desirable to utilise the higher ranges of cruising speed.

Engine

The engine fitted as standard is the "Gipsy Major" manufactured by The de Havilland Aircraft Co. Ltd.

The "Gipsy Major" is dealt with in detail in another section, and should be referred to for particulars of construction, operation and maintenance of the engine.

General Data

The Leopard Moth is a single-engined high-wing monoplane with folding wings and the following are its leading particulars as to weight, dimensions and performance weights (approximate):—

	Lbs.
Tare weight (including standard removable equipment)	1,375
Fuel (35 gallons)	263
Oil (2·6 gallons)	25
Pilot	160
Useful load	402
Maximum permissible weight	2,225

Dimensions

	Ft.	Ins.
Length (wings extended)	24	6
,, (wings folded) .	26	6
Span (wings extended)	37	6
,, (wings folded) .	12	10
Height overall . .	8	9

			Sq. Ft.
Wing chord tip	3 ft. 10 in.	Total area of main planes, including C/S . .	206
,, ,, root	7 ft. 1·25 in.	Area of C/S . . .	20
Incidence .	2° 30′.	,, Ailerons (total) .	19·6
Dihedral .	0° 45′.	Folding flaps (total) .	21·4
Sweepback .	6° 38′	,, fin . . .	4·34
Airscrew diameter	6 ft. 9 in.	,, rudder . . .	7·69
Ground clearance	12·5 in.	,, tailplane . .	14·32
Ground angle.	13°	,, elevators (total) .	13·30

Performance

	Normal Weight, 1,850 lbs.	Maximum Weight, 2,225 lbs.
Maximum speed at sea level . .	141·5 m.p.h.	140·0 m.p.h.
,, ,, 5,000 ft. . .	137·0 ,,	134·5 ,,
,, ,, 10,000 ft. . .	131·5 ,,	127·5 ,,
Cruising speed, 1,000 ft. . . .	120·5 ,,	119·0 ,,
Stalling speed (indicated) . . .	45·5 ,,	50·0 ,,
Length of run to take off . . .	140 yds.	215 yds.
Time to take off	12 secs.	17 secs.
Length of run landing (wheel brakes on)	105 yds.	140 yds.
Gliding angle (air brakes on) . .	1 in 9	1 in 9
,, ,, (air brakes off) . .	1 in 12	1 in 12
Rate of climb at sea level . . .	850 ft./min.	627 ft./min.
Time to climb to 5,000 ft. . . .	7 mins.	9·5 mins.
,, ,, 10,000 ft. . . .	16 ,,	23·5 ,,
Absolute ceiling	21,500 ft.	17,300 ft.
Service ceiling	19,000 ft.	14,500 ft.

RANGES IN STILL AIR AT CRUISING SPEED

Fuel consumption at above cruising speed	5·9 g.p.h.	5·9 g.p.h.
,, ,, ,, ,, ,,	20·4 m.p.g.	20·2 m.p.g.
Ultimate range with 20 gallons . .	408 miles	404 miles
,, ,, 35 gallons . .	715 ,,	707 ,,

Extra tanks can be fitted to meet special requirements.

N.B.—The above mileage is reckoned on a basis of all fuel being used. A safe margin must naturally be allowed when calculating for a journey.

Note

All performance figures quoted are based on the most accurate possible tests carried out in England and reduced to International Standard Atmospheric Conditions. It must be borne in mind that local conditions of temperature, humidity and barometric pressure have an important influence on performance.

Equipment

Cabin heating and fresh air ventilating, fire extinguisher and wiring for navigation lighting is standard equipment.

Construction of the Leopard Moth

The wings are braced with steel streamline Vee lift struts to a joint on the bottom of the fuselage in line with and below the rear spar.

Main Planes

The main planes are of very robust construction, each plane consisting of two substantial box section spars with spruce flanges and 3-ply webs, and a leading edge of ply covering to front spar, the ply also extending on underside of plane to rear spar on inner bay, *i.e.*, from root out to lift strut joints. A stout spruce diagonal member is used for internal bracing in the inner bay and normal wire bracings in the outer bays. A fuel tank is housed at the root end of this inner bay. The ribs are closely spaced, those in the inner bay being all of built-up ply webbed type and those in the outer bays of both ply webbed and normal light rib construction. The wing tip bends are of laminated spruce and the trailing edge of normal wood section.

The differential aileron gear is mounted vertically on the web of the rear spar, the push-pull rod being connected to the upper flange of the aileron spar.

The aileron is constructed with a built-up spar of spruce flanges and ply web, light diagonal ribs and ply covering. The whole is covered with doped on fabric.

Tail Unit

The tail plane consists of spruce spars of spindled I and channel section, stiffened with spruce ribs and formers, the whole being covered with 3-ply. The 3-ply is covered with doped on fabric.

The tail plane is hinged at the rear spar and supported at the apex of the front spar by a tube adjustable in length by means of a screw gear capable of being rotated by cables operated by the handwheel in the cockpit. The tail plane is rigidly braced by streamline wires to the top of the fin post and to the bottom of the fuselage.

The elevators comprise spruce spars and braced diagonal ribs so arranged to take torsional loads. The left and right elevators are coupled together at the centre by a steel fitting which incorporates the control lever.

The rudder is constructed on similar lines as the elevators.

The fin consists of a spruce spar and ribs covered with 3-ply. The 3-ply is covered with doped fabric and as both the tail plane and fin depend on the 3-ply skin for their torsional stiffness, it is important that the aeroplane should not be flown with this ply seriously damaged.

The longitudinal trim is controlled by a large diameter handwheel, which by means of cables rotates the screw gear attached to the tail plane front spar. The operating load in the cables has been kept small so as to avoid stretch and subsequent backlash in the mechanism.

Fuselage

The fuselage portion forward of the door pillar is of welded square section steel tube, the remainder of the fuselage to the tail end being of wooden construction with spruce longerons and members with 3-ply covering. On early aeroplanes the ply covering formed the external surface of the fuselage and was painted and finished to the colour scheme required. On later types longitudinal stringers are fitted and the whole covered with fabric and doped.

The joint plates are of steel, the fittings taking the wing loads are steel forgings and steel bar. The roof of the cabin forms the centre section of the wing and is partially formed with flexible transparent windows.

The bolts at all joints are provided with cupped steel washers which allow for natural shrinkage of the timber to take place without the consequent loosening of the bolts.

The compression loads at the rear spar hinge joint and the attachment joint for lift struts on the bottom longerons are taken to the fuselage cross members by means of compression studs, which avoid pressure on the longerons and fuselage member. The compression studs are lengths of steel rod just the thickness of the longeron, and allow the making of a complete metal structure between the fittings inside and outside the longerons.

Special protective measures are also taken; all plywood is covered with fabric which is attached in the first place with a cellulose adhesive and finally the whole structure is protected with a nitro-cellulose finish.

Further precautions have also been taken to counteract the disintegration effect of condensed moisture at the junction of the rear fuselage longerons with the 3-ply covering by treating with three coats of varnish.

Pilot's Windows

The pilot's windows are of safety glass and afford a particularly good

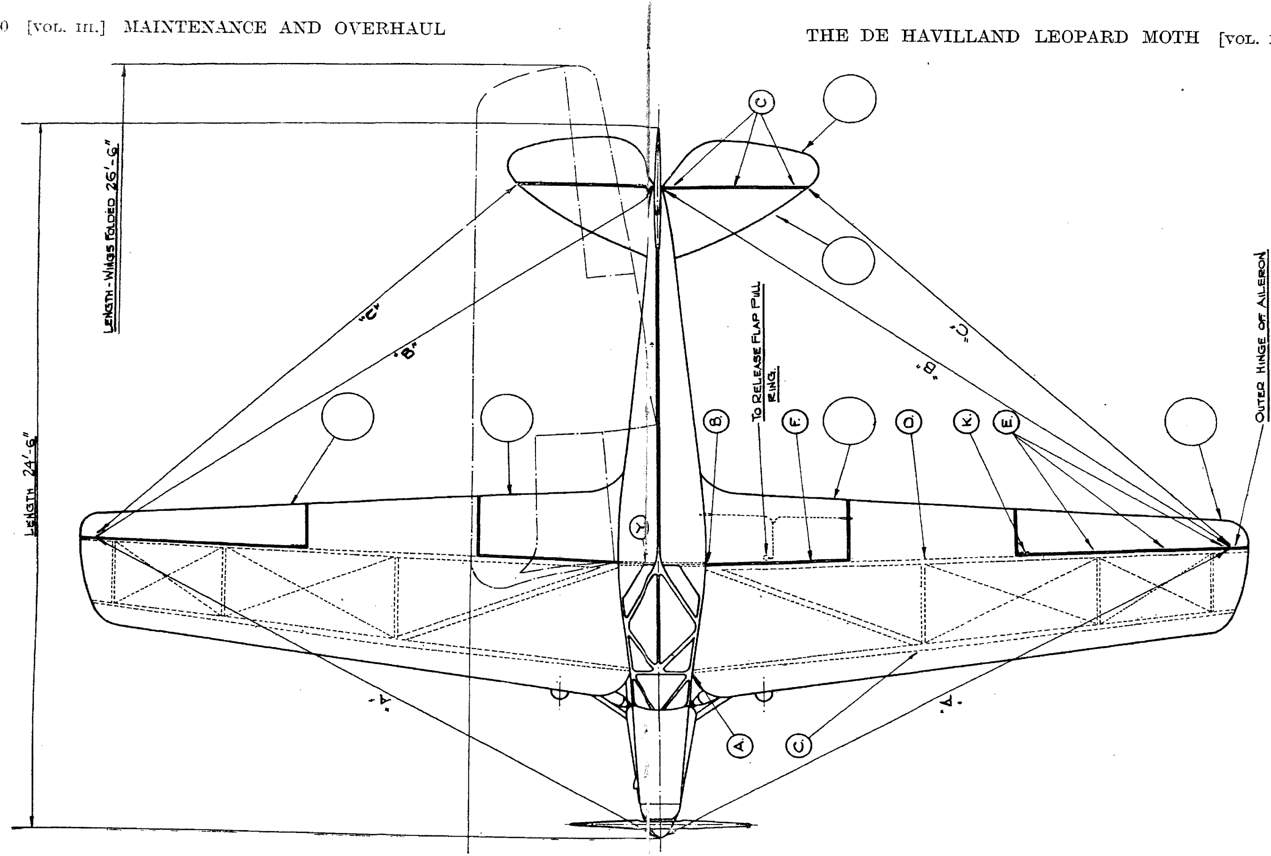


Fig. 1.—RIGGING DIAGRAM (1).

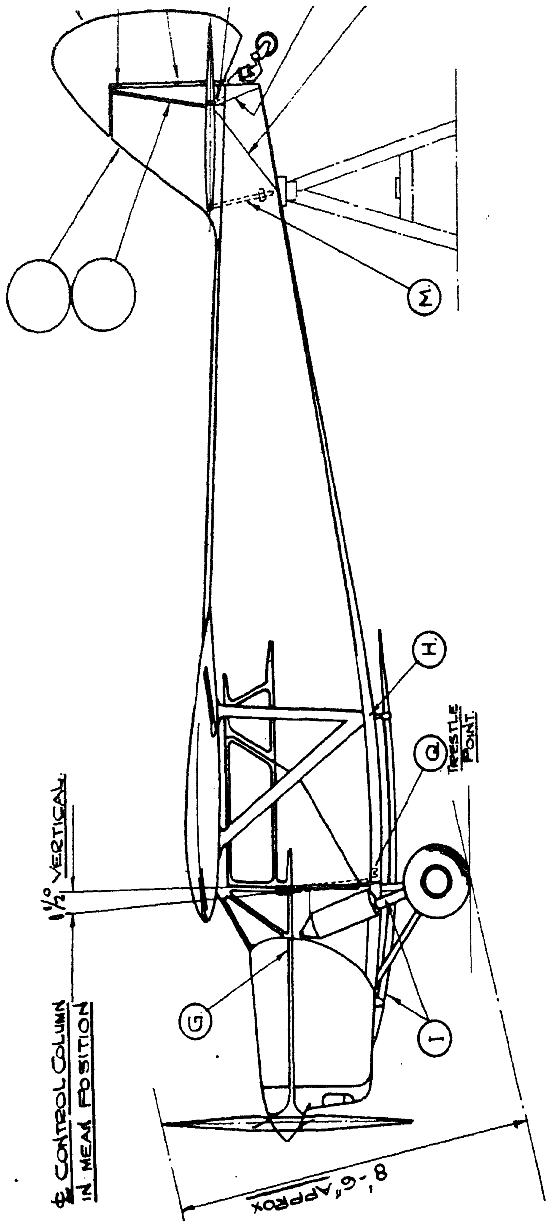


Fig. 2.—RIGGING DIAGRAM (2).

view for flying and landing. The cabin side windows are of transparent flexible sheet, which can be kept in perfect condition if periodically washed with clean water and polished with metal polish, using a soft clean cloth. The cabin door windows can be opened for ventilation purposes.

A door is provided on each side of the cabin and an emergency exit in the roof. Controllable heating and ventilating devices are fitted as standard, and a pilot's locker is fitted between the rudder bar bearers, also two lockers under the seat at back and a luggage space behind. Access to the luggage space is gained by folding forward the adjustable head rest.

Control Column

A control column of normal type is fitted as standard, but wheel control for the ailerons can be supplied to special order. The rudder bar is fitted with rudder bias gear, which can be trimmed to overcome

the airscrew slipstream effect on the tail. An airbrake lever is fitted on the right side of the cabin, which operates through bevel gearing the fairing on compression legs, rotating the same through 90° and bringing the flat side of the fairing into wind.

Provision is made for the fitting of dual control, but full dual control is not fitted. The necessary rudder bar and mechanism are, however, supplied as an alternative to the passenger's footrests.

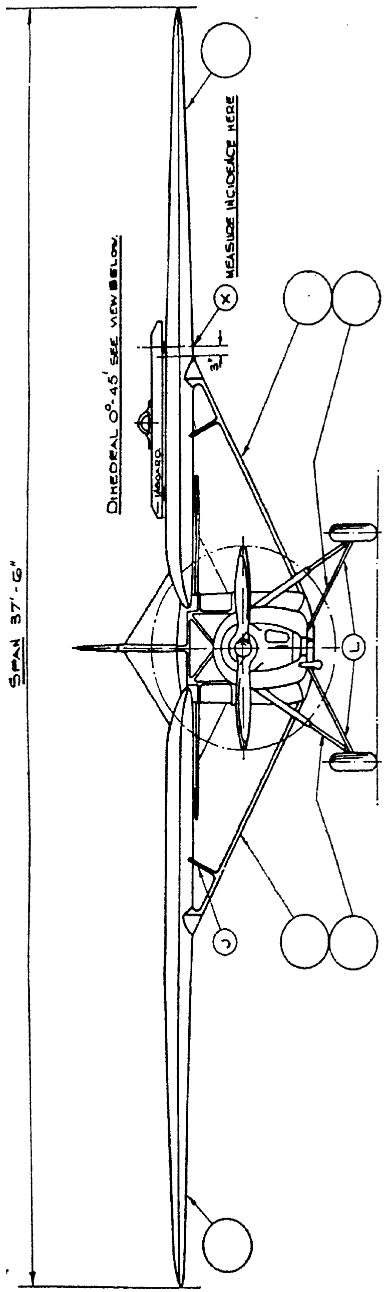
Control Cable

All control cables are carried under the cabin floor and are protected from weather by a fabric covering provided with large fabric panels secured with hook lace fasteners to allow of inspection with the minimum of trouble.

The rear fuselage is provided with holes in the bottom covered by tear-off patches to enable a thorough inspection to be made of the interior.

Engine Mounting and Tanks

The engine mounting consists of a welded square-section steel tubular structure attached at four points to the fuselage and incorporates vibration-damping rubbers on which the engine is mounted. A metal and asbestos fireproof bulkhead is



—RIGGING

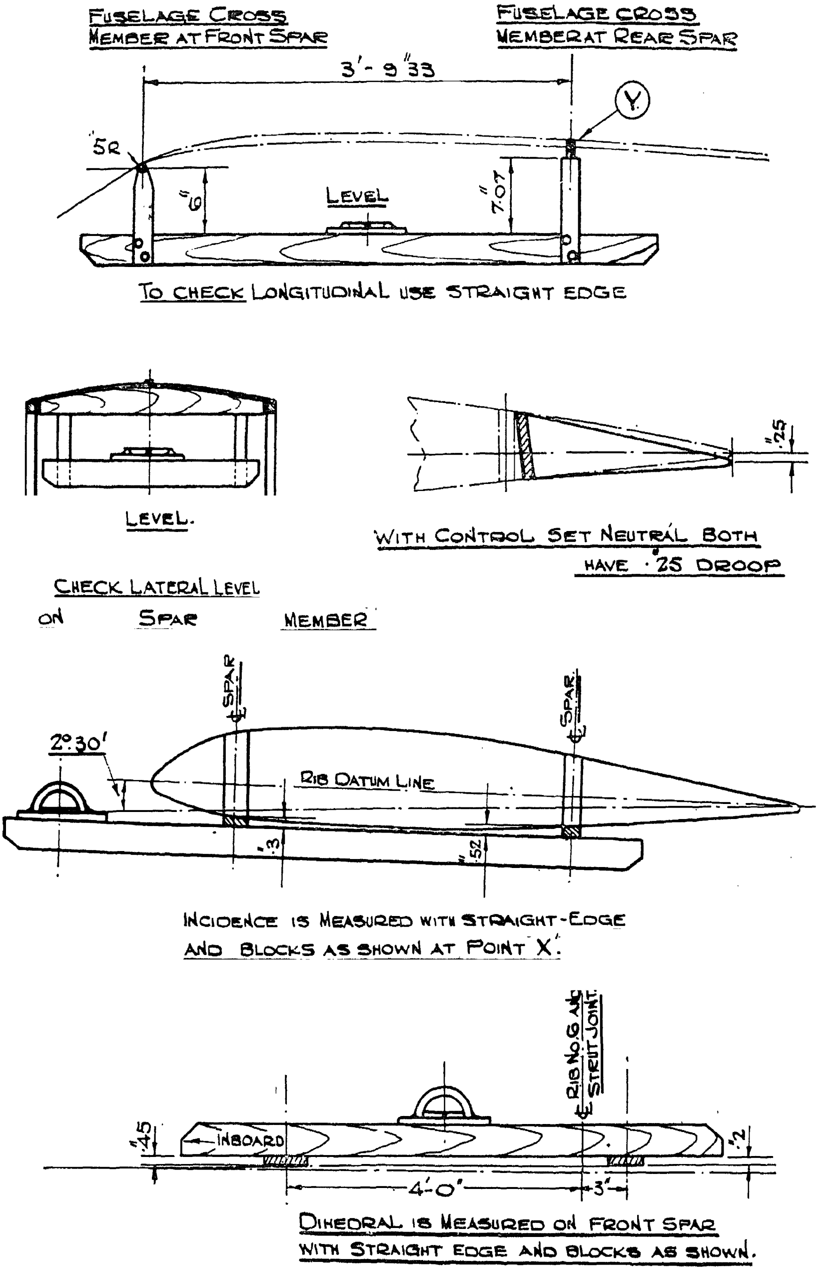


Fig. 4.—Rigging diagram (4).

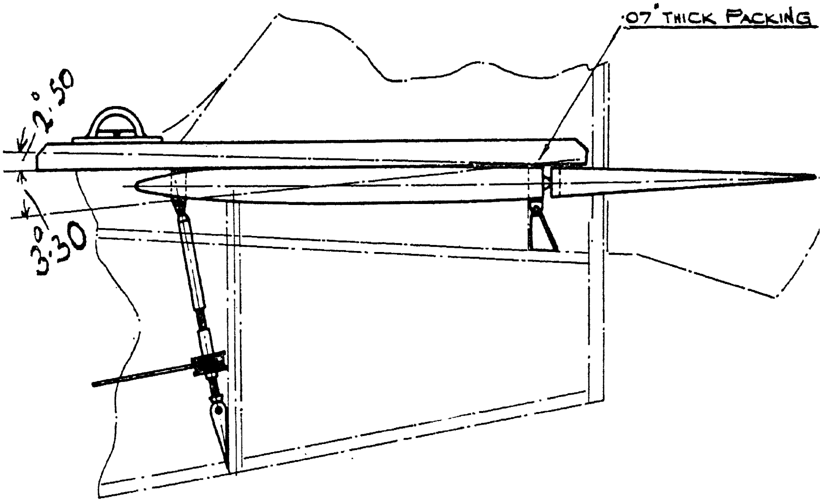


Fig. 5.—RIGGING DIAGRAM (5).

METHOD OF MEASURING TAIL PLANE ANGLES

Angles of tail plane may be measured from top of spars with straight edge placed 8 in. from and parallel to C/L of machine. Use packing ·07 in. thick on top of rear spar to allow for difference in depth between front and rear spars.

Check lateral level on rear spar.

Elevators to be in line with tail plane when in the mean position and the control column set neutral, *i.e.*, $3\frac{1}{2}°$ forward.

ANGLES AND LIMITS FOR RIGGING

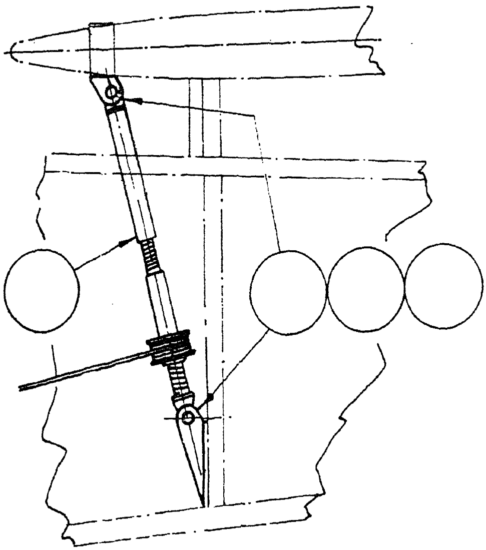
	Setting.	Limit of Error.
Dihedral . . .	0° 45′	± 0° 20′
Incidence . . .	2° 30′	± 0° 15′
Aileron droop. . .	·25 in.	± ·05 in.
Lateral level of tail plane	Level	± 0° 15′
Angular range of tail plane	2° 50′ up 3° 30′ down	± 0° 15′
Fin post . . .	Vertical	·13 in. each way.

The following permissible limits of error on assembly apply to dimensions "A," "B" and "C" (see plan view of aeroplane):—

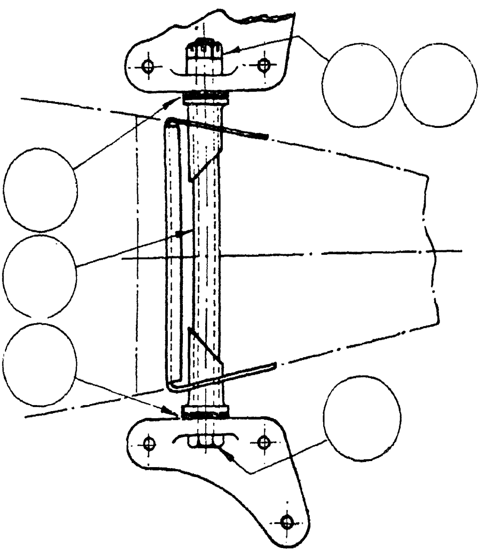
Dimensions "A" to be equal within ± 0·5 in.
Dimensions "B" to be equal within ± 1 in.
Dimensions "C" to be equal within ± 1 in.

fitted between the engine and the cabin, the oil tank being mounted in a trough just behind this bulkhead and cooled by air deflected from a scoop.

One fuel tank of $17\frac{1}{2}$ gallons capacity is carried in each wing root and slung from brackets on front and rear spars by cables covered with rubber to damp out vibration. The tank is made of welded aluminium and a fuel level gauge mounted on the tank sump projects below the underside of the wing and is visible from the cabin.



TAIL PLANE RAISING GEAR.



TAIL

Fig. 6.—RIGGING DIAGRAM (6).

Fuel and Oil System

Fuel supply is by gravity feed direct from the wing tanks; total tank capacity 35 gallons. The fuel cock controls are just above the doors in the cabin, these are pushed in for "off" and pulled out for "on."

Oil is supplied from a tank (2 gallon capacity on early aeroplanes and 2·6 on later) attached to the fireproof bulkhead. The oil is drawn by the engine pump and passes through a filter on the engine before entering the engine. Return to the tank is by means of a scavenger pump on the engine. A filter is also provided on the engine on the return side.

Undercarriage

The undercarriage is of the divided type, with half-axles and radius rods hinged to the underside of the fuselage, and long shock absorber legs attached to the fuselage at the base of the windscreen. The springing of the shock-absorber legs is by means of rubber-in-compression, and the fairing of these units when turned through 90° form the airbrake.

Dunlop low pressure tyres, $7\frac{1}{4}$ in. for $7\frac{3}{4}$ in., are fitted as standard and the tyre pressure should be maintained as described later under the inspection

notes. Bendix brakes are fitted as standard.

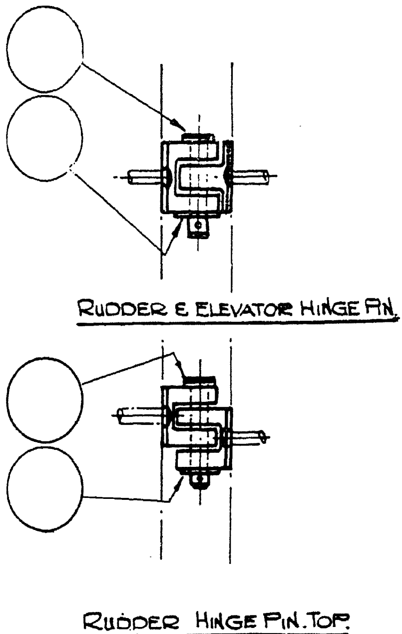
Tail Wheel

A fully castoring tail wheel is fitted with shock-absorbing device of rubber block in compression. Particular attention has been paid to provide large bearing surfaces at moving points and nipples for grease gun lubrication are placed where necessary.

Bobbins are fitted to each end of the wheel spindle to take a steering bar to facilitate wheeling the aeroplane about.

RIGGING THE LEOPARD MOTH

To assemble the aeroplane from the ground up, it is first necessary to support the fuselage on trestles at the points indicated on the rigging diagram, allowing sufficient clearance from the ground for the undercarriage to be assembled. A weight of approximately 75 lbs. should be slung from the tail wheel bracket as a precaution against any tendency of the fuselage to tip forward due to the weight of the engine. Lateral level can be checked by placing a level on a straight-edge held parallel to rear spar cross



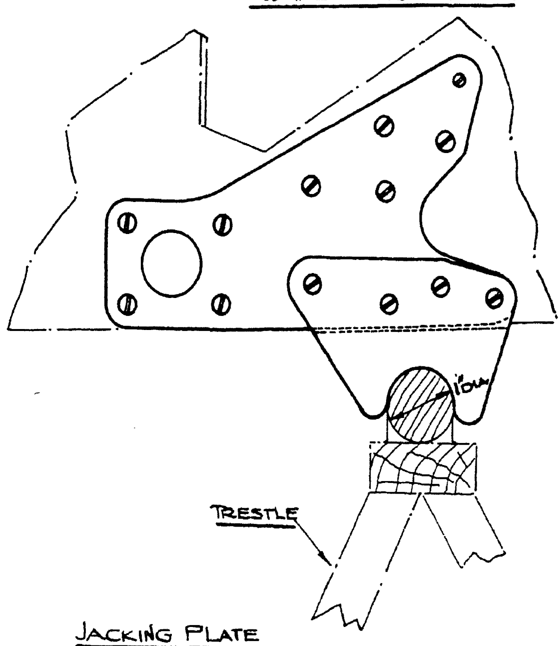


Fig. 7.—RIGGING DIAGRAM (7).

member in the cabin, while to check fore and aft level a straight-edge must be suspended below the front and rear spar cross members at 6 in. and 7·07 in. below the same respectively.

The main planes should now be fitted, using trestles to take the weight, and when the joints to the fuselage have been secured, the Vee lift struts and small stabilising struts may be assembled. The rear lift strut is adjustable at the top end to obtain correct incidence.

Check the levelling of the fuselage and re-adjust if necessary and then proceed with the trueing up.

For general information the rigging diagram can be consulted, but the actual angles to which a particular aeroplane was passed out by the constructor are given in the Aircraft Log Book.

Tail Unit

The tail plane is assembled at the front spar by the adjustable gear and at the rear spar by means of a bolt passing through the pivot bracket and clamping on to a distance tube passing through bearings on the fuselage. Shims in the form of washers are used between the fuselage bearings and the tail plane pivot brackets to take up side play.

The fin is now assembled by bolting to the bracket on the stern post and at the forward end bolting to the raised structure at the rear end of the fuselage.

The rudder and elevator are to be fitted and finally connect up the control cables to same.

Special care is necessary when carrying out the rigging adjustment to the tail plane to ensure that the tail plane bracing wires will be adequately tensioned for the whole range of the tail plane incidence. In order that this procedure may be carried out the tail plane should be set in the neutral position as determined from the indicator adjacent to the tail plane adjuster wheel and all external bracing wires adjusted to the normal tension. The bottom rear bracing wires are then to be given an extra half turn.

Undercarriage, Assembly

The undercarriage may now be assembled, the attachment joints being shown on the rigging diagram. The radius rods being triangulated, no adjustment is made or necessary to rig the undercarriage correctly.

Brake Operating Cable in Undercarriage Strut

The mechanism is shown diagrammatically on Fig. 8 and the method of adjustment is described later.

The following describes the method of coupling up the cable in each rear radius rod to the cables in the fuselage.

The cables are in two parts; one guided over the pulley at the top of the strut, the other consisting of a cable enclosed in an armoured casing leading from the brake drum to the interior of the strut.

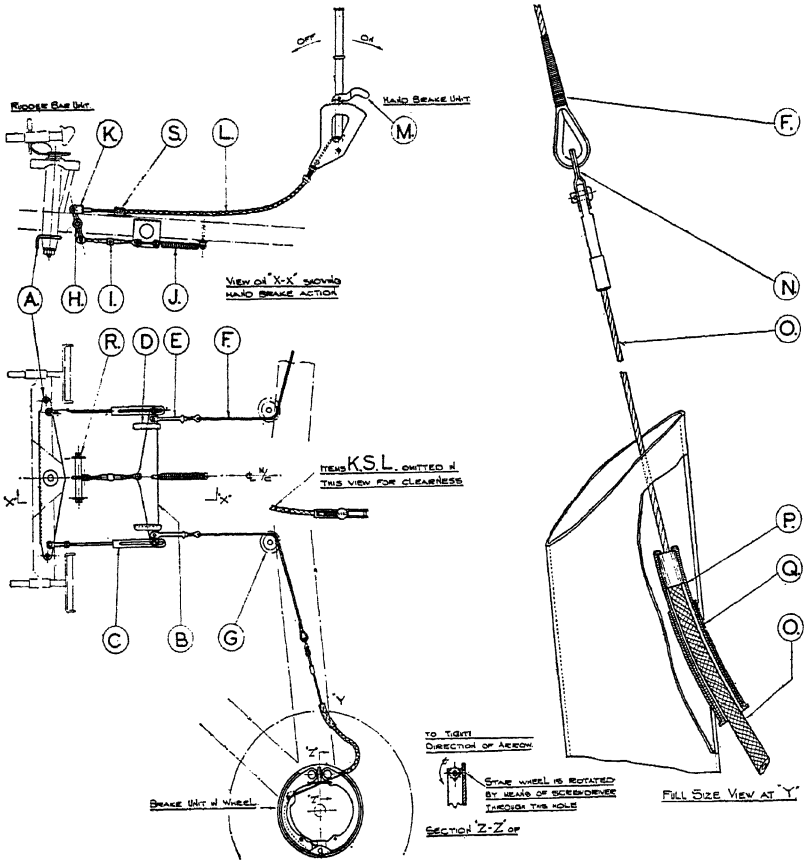


Fig. 8.— OPERATING MECHANISM.

(A.) Rudder bar lever. (B.) Compensating bar. (C.) Link rods. (D.) Guide plates. (E.) Adjuster for operating cable. (F.) Operating cable. (G.) Guide pulley. (H.) Rocking lever. (I.) Adjuster for hand brake control. (J.) Return spring. (K.) Shackle. (L.) Hand brake lever cable. (M.) Hand brake locking pawl. (N.) Shackle. (O.) Brake unit cable and casing. (P.) Inner stop sleeve. (Q.) Outer stop sleeve. (R.) Rocking lever pivot pin. (S.) Stop for hand brake cable.

To get at the junction, it is necessary to disconnect the cable adjusters and remove the pulleys; when this is done the cable can be pulled through the sleeve at the lower end of the strut. The shackle is now fixed to the eye end of the cable by means of a pin and locked with a split pin. The inner stop sleeve is assembled on the armoured casing by passing the cable through the slot provided in the sleeve.

The cable can now be pulled back in the fuselage and the outer stop sleeve pushed into the fixed sleeve. The cables should now be joined up

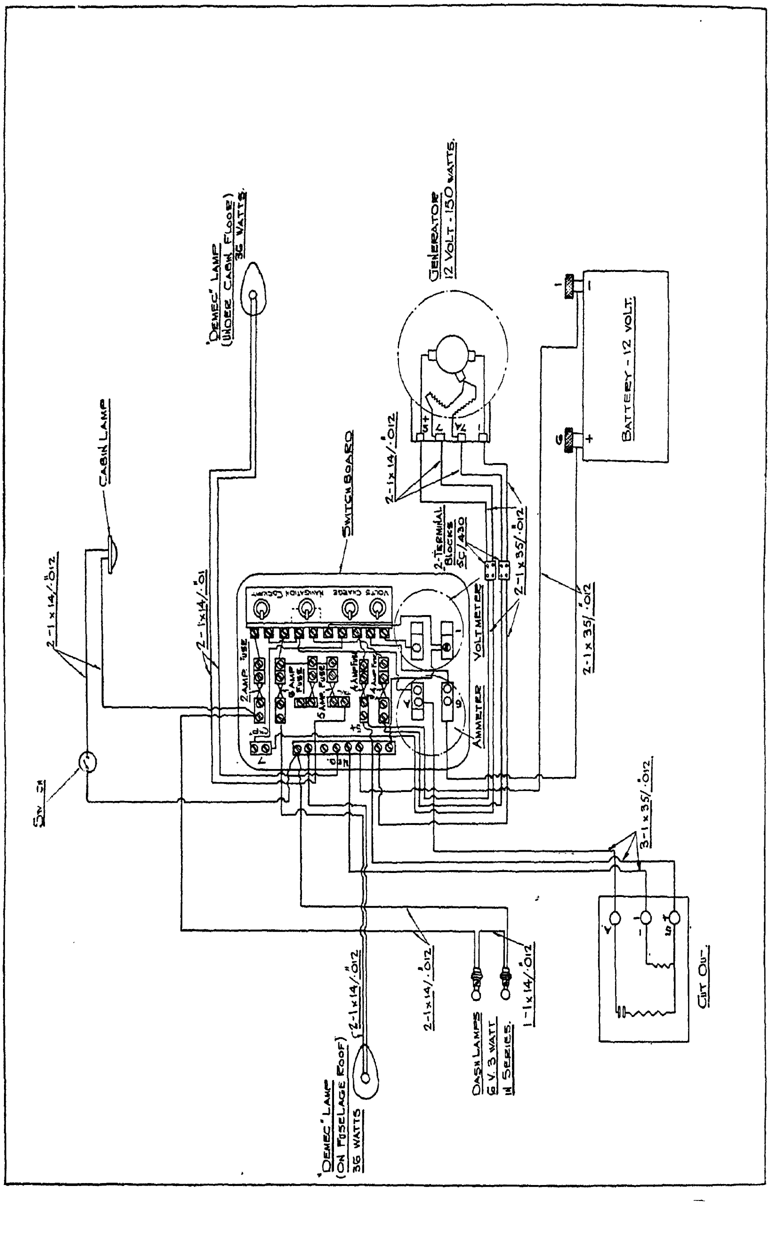
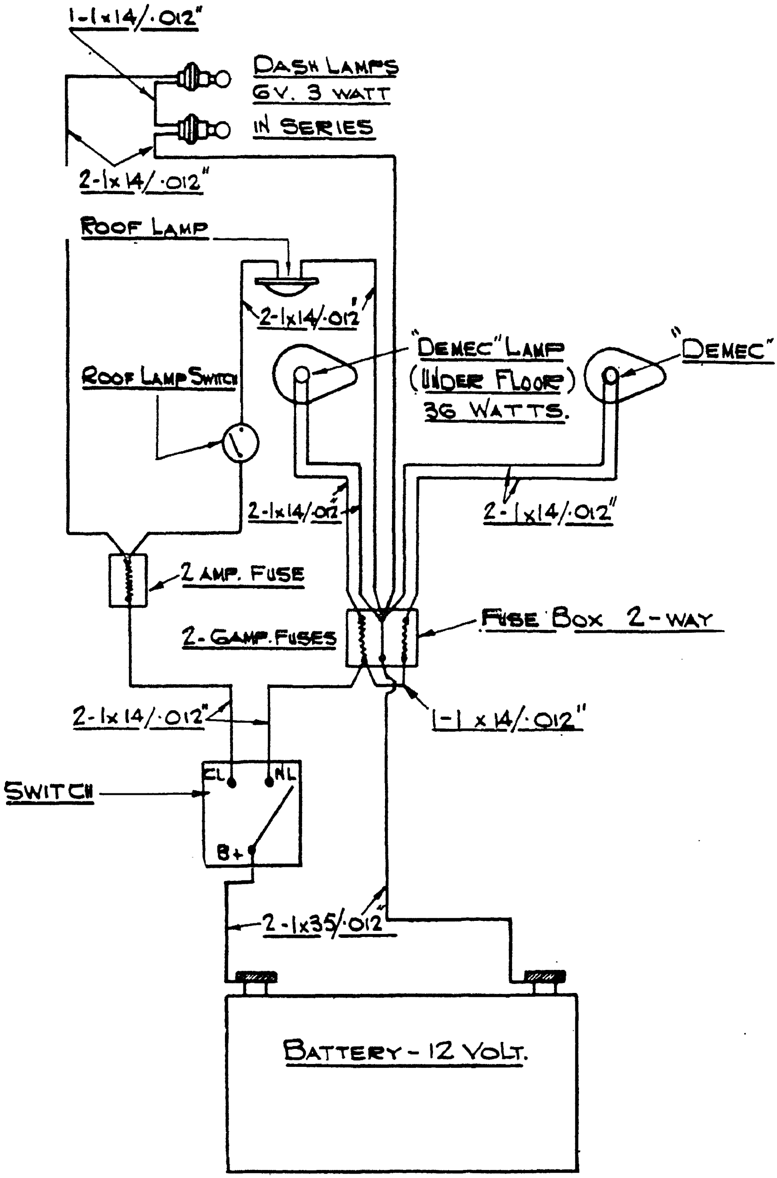


Fig. 9.—Lighting Equipment (with Generator) Wiring Diagram



10.—LIGHTING EQUIPMENT (WITHOUT GENERATOR) WIRING DIAGRAM.

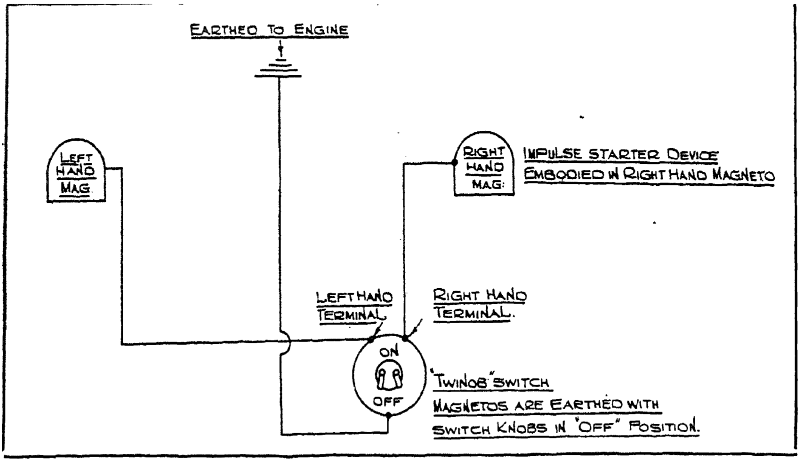


Fig. 11.—IGNITION WIRING DIAGRAM.

to the compensating bar by means of the adjuster and the pulleys bolted back into place.

Adjustments can now be carried out as follows :—

Brake Adjustment

Major Adjustment

Note this adjustment is only necessary for initial setting of the operating cables at the works, or if the chassis has been dismantled, or when new shoes are fitted :

1. Jack aeroplane up on the jacking plates provided on fuselage bottom joints and remove wheels.

2. Approximately centralise shoes.

3. The hand lever in the " off " position forms the stop for the compensating bar and, with the hand brake hard on, the pins on the compensating bar should be midway in the slots of the connecting links.

This point should be checked up first, putting the hand lever eight notches on, any adjustment to centralise the pins in the slots being done by means of the turnbuckles attaching the hand brake cable to the centre of the compensating bar. At the same time it should be checked when the hand lever is put off that the compensating bar is clear of the aft end of the slots in the guide plates. If this is not so, connection can be made first by shortening the slotted connecting links by turning the fork ends, and then again adjusting turnbuckle to suit.

4. With the hand lever in the " off " position adjust the turnbuckles securing the cables to the ends of the compensating bar, so that the operating cam in the brakes is just touching the shoes without actually expanding them. The wheel should then be put into place.

5. It should now be ascertained if the brakes are free when the rudder

is centralised, and also that the full rudder movement is obtained in both directions. A check measurement taken between the tip of the balanced portion of the rudder and the fin should give not less than 7·2 in.

6. The hand-brake lever quadrant is provided with an adjustment to take up any stretch which may occur in the Bowden cable. (This adjustment should not be used to take up wear, for which see below.) The pawl on the hand lever is not self-engaging, it is necessary to engage this with the ratchet to hold the brakes in the " on " position.

Adjustment for Wear

This is carried out by rotating the star wheel by means of a screw-driver inserted in the slot provided, and the hand should move inwards towards the axle to expand the brake by using the slot in the casting as a fulcrum.

Caution.—The adjusting turnbuckles must not be used to take up linings, but only for initial setting or to compensate for any stretch in cables. Stretch should be negligible as the cables are proof-loaded to half their breaking strength before fitting.

Differential Aileron Control

Should the angle of the connecting rod between the aileron and control chain sprocket on the rear spar become disarranged for any reason, such as the dismantling and reassembling of the planes, care must be taken to see that this connecting rod is positioned as before, *i.e.*, at an angle of 52½ degrees to the vertical. This can be conveniently done by lining up the marks painted on the sprocket and on the face of the rear spar. It is important to see that this angle is the same on both sides of the aeroplane when the control stick is set central.

A droop of approximately ¼ in. at the trailing edge should be allowed on the ailerons.

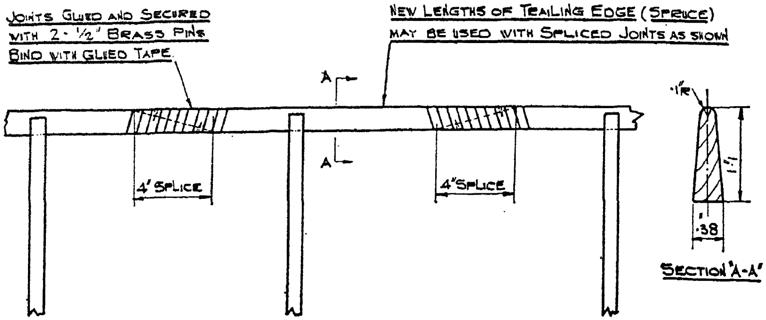
The operating chain on the sprocket is to be set central when the crank lever is as indicated above and the aileron droop fixed. Any further slight adjustments between the control stick and the aileron gearing can be made on the aileron turnbuckles. Also, aileron push rods are adjustable, but these, once set, should not be altered unless for reasons outlined below.

If the aeroplane shows a tendency to fly one wing low, first check the rigging of the wing structure and note that the aileron crank lever is correctly set. Should these points be found correct, the trouble may be due to slight warping of aileron spars.

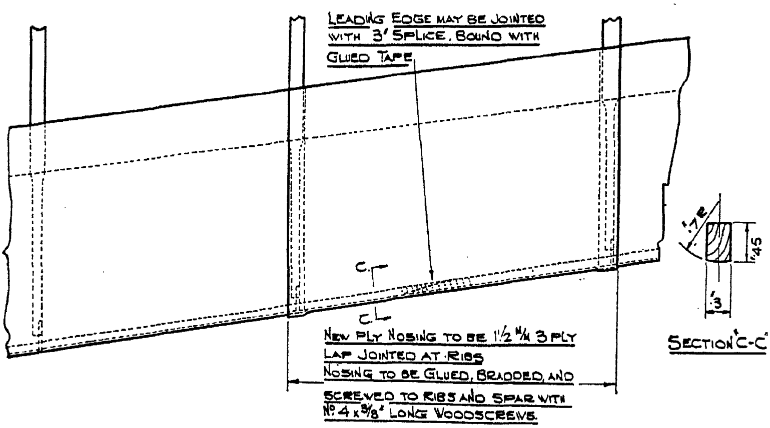
Rectification should be made in the following manner :—

(*a*) Disconnect both push rods between the sprocket wheel levers and the aileron levers.

(*b*) *Lengthen* the push rod on the side which tends to fly *low* by unscrewing the adjustable end by one turn, *shortening* the rod on the other side by a corresponding amount.



Repair to Trailing Edge of Main Planes



Repair to Leading Edge of Main Planes

Fig. 12.—LEADING AND TRAILING EDGE REPAIRS (1).

(*c*) Reconnect the push rods.

If this adjustment proves insufficient to correct the trim of the aeroplane, the operation should be repeated until the fault is overcome. Care should be taken, however, that it is not attempted to put an incorrectly rigged aeroplane in order by this means. It should never be necessary to shorten or lengthen the adjustable push rods by more than two, or at the most three turns.

Operating the Leopard Moth

Folding the Planes

When it is desired to fold the planes, the trailing edge flaps should

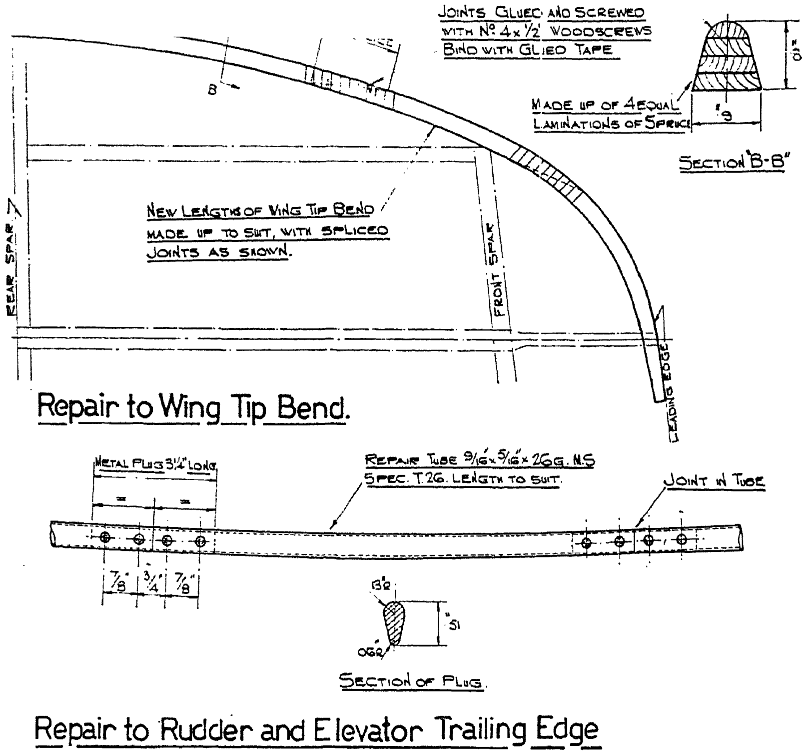


Fig. 13.—LEADING AND TRAILING EDGE REPAIRS (2).

first be folded up and locked in place on the top of the plane. The operating ring for this flap will be found on the underside of the flap adjacent to the hinge gap. After taking precautions to take the "swing-back," the front spar locking pin may now be withdrawn, first by turning the safety catch through 90 degrees, and then by pulling the release ring which is situated near the joint attaching the lift strut to the front spar. After folding the plane it must be locked in position by means of the slip bolt provided on the side of the fuselage.

To close the planes the above procedure is reversed, and when the planes are in position *it is imperative that the locking pins are pushed right home and that the safety catch is in the locked position,* i.e., *turned to be in line fore and aft.*

Engine Revolutions

All-out revolutions on the ground are approximately 1,850 to 2,000, and are often governed by the design of the particular airscrew utilised. Flying level, the maximum permissible revolutions are 2,350 per minute,

but the engine should not be run for more than short periods at high revolutions.

In order to avoid extravagance in fuel and oil and unnecessary wear of the engine, it is recommended that the engine should be cruised at 1,900 to 2,050 r.p.m.

Fuel System

The fuel tanks are fitted one in each wing. Each tank is of $17\frac{1}{2}$ gallons capacity and is fitted with cork-faced fuel cocks, operated by a push-and-pull rod on each side of the cabin, in easy reach of the pilot. Hence the tanks may be used together or independently. A fuel gauge consisting of a plunger in a glass tube below the tank gives a reading, in level flight, of the amount of fuel in either tank. Air vents are placed on the top of each tank immediately behind the filler cap. The hole in the top of the air vent pipe must always face forward and be kept clear of obstructions. The main fuel filter is situated on the front of the engine bulkhead.

The fuel is fed to the carburetter by dual D.H.A.C. engine-driven fuel pumps.

After a tank has been run dry or after cleaning the filter it is found that there is a danger of trapping air, which may affect the fuel flow when next starting the engine. After refitting the filter it is advisable to disconnect the fuel pipe at the pump end and allow the fuel to flow until a full bore, with no air bubbles, is obtained. Then connect the pipe to pumps whilst the fuel is flowing, thus ensuring there will be no air lock.

Fuel Tanks

When operating under extremely cold climatic conditions, failure to give reasonable attention to the draining of condensed moisture from the fuel tanks may result in sufficient water collecting in the gauge glass to freeze, with the possibility of either freezing in the knob of the fuel level indicator and giving a false reading of the contents, or even perhaps bursting the gauge glass.

Range and Capacity

The full 35 gallons fuel capacity (700 miles range) provided in the Leopard Moth should only be utilised when required. For normal everyday flying the tanks need only be filled with 20 gallons (10 gallons each), giving a range of 400 miles (quite adequate for average journeys), thus permitting a saving of some 120 lbs. weight of superfluous fuel with consequent improvement in take-off, general handling and all-round performance.

Tyre Pressure

Tyres should not be pumped up too hard, and a very appreciable flattening should be apparent on the ground. This will result in more

comfortable landing and taxying, and will give longer life and less wear and tear to the undercarriage and structure. The pressure should be 15 to 17 lbs. per square inch for normal loads, *i.e.*, all up weight about 1,900 lbs. with an increase of pressure of $1\frac{1}{2}$ lbs. per square inch for every 100 lbs. above this weight.

Air Brakes

One of the most important features of the Leopard Moth is the provision of air brakes. It is essential that their function should be clearly understood, and particular attention is drawn to the following description and directions for the correct operation.

The high efficiency, together with the general clean design of the Leopard Moth, results normally in an extremely flat gliding angle. While a flat gliding angle may be a great advantage in the rare event of a forced landing having to be effected, it is inconvenient in making a normal landing. For this reason a simple but most effective air brake is incorporated. The undercarriage compression struts are of streamline section, and extend from the fuselage side to the wheels. By the operation of a lever in the cockpit they are swivelled broadside on to the wind when braking effect is desired. The air brakes have the effect of considerably steepening the angle of glide and stopping "float." The effect may be gauged from the fact that the action of the brakes reduces the top speed by about 35 m.p.h. The brakes are not in any sense an emergency provision, and it is intended that they should be used on all occasions of landing, being normally applied when the engine is throttled down for starting a glide to the landing ground. Due to the proximity of the centre of resistance of the braking surface to the centre of gravity of the aeroplane, the application of the brakes at full speed or low speed can never upset stability or control. The brakes can be moved into flying position at any time after landing.

INSPECTION OF THE LEOPARD MOTH

(a) **Before each Day's Flying**

1. Inspect airscrews.
2. Inspect all covered surfaces for holes in fabric.
3. Check free movement of all controls.
4. Verify that engine cowling is properly fastened.
5. Verify that locking pins at front spar joint to fuselage are right home and that the safety catch is in locked position, *i.e.*, in line fore and aft.
6. Inspect undercarriage and tail wheel gear for any signs of abnormal landing stresses.
7. The accuracy of the airspeed indicator may be checked in the air by gently stalling the aeroplane and observing if the reading of the indicator corresponds with the known stalling speed at that particular load.

(b) After a Bad Landing

1. Examine shock absorber leg units, axles and radius rods. If any signs of bowing are apparent, components affected should be replaced, as strength is impaired.

2. Examine wheels.

3. Examine attachment joints to main structure, verifying that no displacement, partial shear of pins or elongation of holes has occurred.

4. Examine fuselage members forming the structure between attachment joints, tail wheel gear, and adjacent fuselage structure. Rucking of fabric or plywood and cracking of paint are indications that opening up is advisable.

5. If the wing tip has come forcibly into contact with the ground or other object, the most likely place in which to look for damage is at or round the point of attachment of the lift struts and the root and attachment joints to the fuselage structure. The outer aileron hinge joint on the rear spar should also be carefully inspected. These points can be examined by making small incisions in the fabric coverings, which must, of course, afterwards be sewn up and covered with doped-on frayed-edge patches, at least 1 in. larger all round than the size of the cut.

6. In the event of a mishap in which the airscrew comes into contact with some object, or, in the case of the aeroplane going on its nose, all engine cowling should be removed to allow an adequate inspection. The ultimate extent of the examination would be determined by the nature and severity of the mishap, but in all cases a special point should be made of checking the crankshaft and the flange of the airscrew hub for truth, the front engine thrust race cover for displacement or damage, the engine bearer arms, attachments to the crankcase and engine bearer arm housing. The actual engine frame structure, and its attachments to the main structure, should also be carefully inspected.

(c) General Points

1. As indicated, all under-carriages using compression rubbers for springing must be kept under observation and periodically jacked up clear of the ground to check the free movement of the sliding portion of the leg which will develop due to rubber settling down or deteriorating.

The amount of free movement permissible in the case of the Leopard is 1·4 in.

Where this is exceeded the leg must be dismantled and if the rubbers appear to be in a bad and distorted condition, replaced by the new ones. If the rubber, however, appears to be in reasonable condition and merely settled down, this can be taken up by fitting an additional rubber, making nineteen rubbers in all (per leg).

2. The straightness of the main wing struts is of great importance and for the guidance of all concerned the permissible bow is given—measuring from a point 14 in. from centre of lower attachment eye the

permissible bow of the front strut over a length of 4 ft. 8 in. is 0·12 in., and the rear strut over a length of 5 ft. 3 in. is 0·14 in.

3. The transparent roof panels are of large area and may shrink with age or atmospheric conditions. This should be made an inspection point, and if there are any signs of pulling away, the attachments should be strengthened in accordance with the maker's drawing.

4. It is imperative that the engine should be correctly mounted in its rubber blocks, otherwise rough running and vibration may result. The caps over the rubber blocks must be fitted to give no clearance between bottoms of caps and tops of rubber blocks, but there should be no pressure on the rubber. This may necessitate the insertion of washers under the caps in order to raise them and prevent pressure on the rubber blocks.

When adjustments are made to the slow running and positions finally determined, it is important that the magneto control should be inspected to see that the magneto is fully retarded; should this not be the case the adjustment control rod to the carburetter should be adjusted for length so that the magneto control ram is in the full retarded position. Adjustments for slow running mixture, if necessary, should be made in the usual way.

"BRISTOL" MERCURY VII, VIII & IX AERO ENGINES

COMPLETE OVERHAUL

By Edmund G. Holt

A COMPREHENSIVE kit of tools is available for each engine which will be found adequate for all normal requirements, and it is most essential that only the specific tools provided be employed.

Components such as connecting rod wrist pins, gudgeon pins, etc., and all ball and roller bearings should be segregated in suitable containers to minimise the possibility of their being damaged (Fig. 1). Where necessary the containers should be numbered or the parts labelled to ensure that they are subsequently replaced in their original positions on the engine.

REMOVAL OF ENGINE FROM AIRFRAME

Wooden Airscrew

Withdraw airscrew and hub as a unit. Remove front circlip (early engines), or take out bolt (later engines) and remove locking washer. Screw left-hand threaded withdrawal nut (supplied in tool kit) into hub, then unscrew shaft nut, thus withdrawing hub.

V.P. Airscrew

To remove a V.P. airscrew, disengage cylinder head locking ring and unscrew cylinder head with spanner provided. Remove split pins to release piston locking ring and, using the same spanner, unscrew piston, thus withdrawing hub from airscrew shaft taper.

Exhaust Ring

Before removing exhaust ring, dismantle V.P. airscrew front oil pipe which runs from No. 1 crankcase bolt to the oil transfer housing on the reduction gear casing. Next remove nuts and bolts securing branch pipe sleeves and slide sleeves towards cylinders. Remove nuts on cylinder port studs, detach branch pipes and remove attachments to tail pipe. Release lock washers of nuts securing the six tie tubes to crankcase bolts, also lock washers of nuts securing the three front struts to the front cover studs. Support the exhaust ring, after which remove both sets of nuts and lift the ring, complete with tripods, away from the engine. The procedure is identical for a double outlet ring.

If so desired, the removal of exhaust ring may be deferred until engine has been lifted out of airframe and is mounted on engine stand.

Pipes

Disconnect fuel pipe at carburetter, uncouple oil pipe-lines between tank, carburetter and engine, disconnect pipe to priming union on volute casing and any other pipes necessary for free withdrawal of engine.

Controls

Disconnect all engine controls, including link rods, from airframe levers to throttle and mixture controls, carburetter cut-out valves, magneto controls, air intake shutter controls, etc.

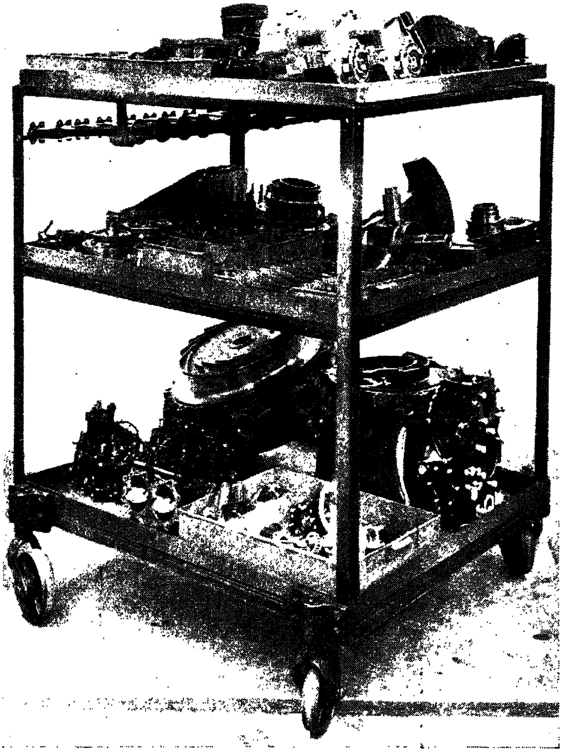


Fig. 1.—SHOWING TROLLEY WITH ENGINE COMPONENTS SEGREGATED IN CONTAINERS.

Magnetos

Withdraw the distributors from both magnetos and fit protective covers provided to prevent damage to exposed rotors when rear of engine passes through aperture in bearer plate. Disconnect main magneto and starter magneto switch leads.

Air Intake and Carburetter

Detach air intake from carburetter flange and then carburetter from engine. This involves removal of automatic boost control piston rod, override control rod and variable datum control rod. Do not disconnect piston rod from toggle links, but detach ends of latter from toggle-link levers on carburetter. Next disconnect upper end of piston rod by turning rod round until cross-pin is aligned with transverse hole in piston rod guide, whereupon pin may be pushed out and rod removed. On no account disturb adjustable eyes on either piston control rod, override control rod or variable datum control rod. Take off nuts and washers and remove carburetter complete from carburetter connection on volute casing.

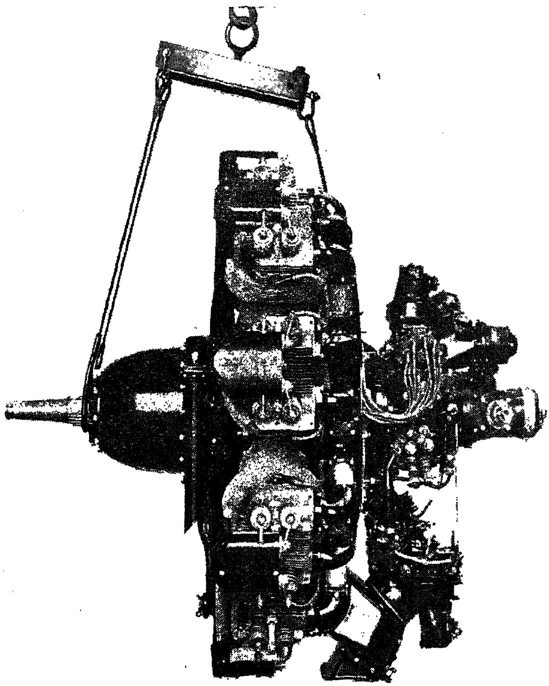


Fig. 2.—ENGINE-LIFTING SLING AND SPREADER.

Rear Cover Auxiliaries

Where an electrical generator is fitted this should be disconnected from the drive. Also remove automatic gun gear, rotoplunge oil pump, R.A.E. air compressor or Romec vacuum pump, whichever happens to be fitted, by unscrewing securing nuts and withdrawing unit complete from rear cover or its adaptor housing as the case may be.

Slinging Engine

A steel cable sling having a spreader is to be used (see Fig. 2). Hook sling on to lifting tackle, place front cable around airscrew shaft, which must be well padded, and attach rear cable to eye bolt on cone mounting, or, if flexible type mounting is fitted, to special lifting link behind No. 1 cylinder. Draw up sling until just taut, to take weight of engine. Unscrew nuts securing engine to bearer plate (eighteen with solid mountings, nine with flexible mountings), after which engine is ready for removal. First, however, make a final check that all is clear and that there is no restriction to free withdrawal of engine from airframe.

Careful manipulation is essential during removal of engine from bearer plate to ensure that no damage is sustained due to fouling.

Mounting Engine on Stand

Mount engine on rotating stand and retain in position by bolts through cone mounting plate. When engine is fitted with flexible rubber mountings, the new type of stand, having nine holes in mounting ring to accommodate the flexible mounting trunnion arms, must be used, or, alternatively, the earlier type may be altered to suit; details of this modification may be obtained from the engine makers.

DISMANTLING THE ENGINE

The sequence of operations given should be closely adhered to when dismantling the engine, as incorrect procedure may result in actual damage to some of the components. For convenience, the procedure for dismantling the various unit assemblies is given in the same section as the instructions for their removal from the engine, but obviously they may be dismantled at a later stage if so desired.

High Tension Wires and Magnetos

Braided Type. The high tension wires need not be dismantled from the fibre carriers in the cone mounting unless a new set of wires is to be fitted.

Detach H.T. wire terminals at sparking plugs and remove plugs. Spring the sleeves holding the wires out of their support clips and disconnect wires at distributor ends by unscrewing union nuts. Tie each set of nine wires together, then remove nuts securing clamps and withdraw clamps ; temporarily secure each set of clamps with wire to prevent loss. Arrange wires around cone mounting so as to permit free access to rear part of engine.

Marconi Harness. Unscrew union nuts securing wires to sparking plug elbows and remove plugs. Spring wires out of top and bottom support clips. Take out the five set screws and remove harness complete with distributors and screws.

Magnetos

On later engines fitted with dual contact breaker magnetos first dismantle magneto interconnecting linkage and remove control brackets complete with levers from rear cover studs.

Remove split pins, unscrew slotted nuts, using spanner provided, and withdraw magnetos. To remove automatic timing device hold magneto in vice with soft metal clamps, release tabwasher locking timing device securing nut and remove nut, after which the driven plate, driving plate and the two springs may be withdrawn. Next withdraw cam plate from magneto spindle taper by means of the extractor (see Fig. 3).

Oil and Boost Control Pipes

Dismantle the high initial oil pressure feed pipe. First unscrew nut securing pipe to sprayer valve cap in oil pump body and withdraw pipe from cap, after which dismantle joint complete with rubber sleeve where it enters cone mounting. Detach upper half of pipe by loosening the two jubilee clips on rubber joint near sprayer nozzle in crankcase.

Next disconnect and remove the two automatic boost control pressure balance pipes, followed by the V.P. airscrew rear oil pipe between rear of No. 1 crankcase bolt and control valve casing on engine rear cover.

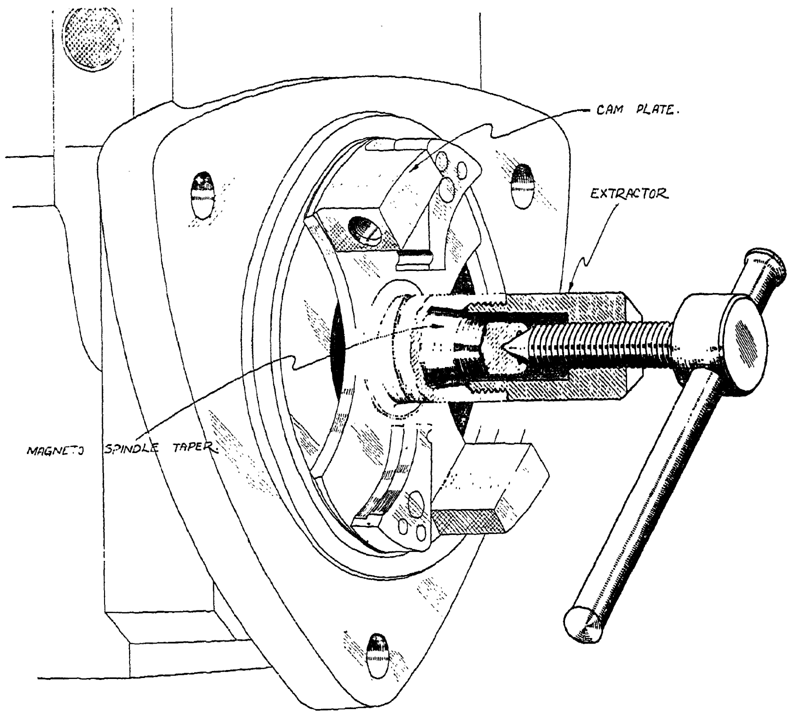


Fig. 3.—WITHDRAWING AUTOMATIC ADVANCE COUPLING CAM PLATE FROM MAGNETO SPINDLE TAPER.

Rear Cover

When dismantling the rear cover from the engine, it is most important to adhere strictly to the following sequence of operations.

Remove starter unit complete.

Take out the wire locking tachometer drive casing screws, remove screws and withdraw drive complete with casing.

Unscrew the nuts securing air compressor to compressor drive casing and remove compressor complete. Remove nuts retaining fuel pump, single or dual type as the case may be, to compressor drive casing and withdraw pump. Next remove nuts securing compressor drive casing to rear cover, taking care to bend back tab of washer locking the one nut situated in the mouth of the drive casing and to remove this nut, after which withdraw casing from studs. When withdrawing the unit care must be taken to catch the small dumb-bell connection which carries the oil from the cross drive shaft to the compressor drive shaft.

When single type fuel pump is fitted direct to rear cover, first withdraw pump from studs, after which release tabwasher locking the bolt

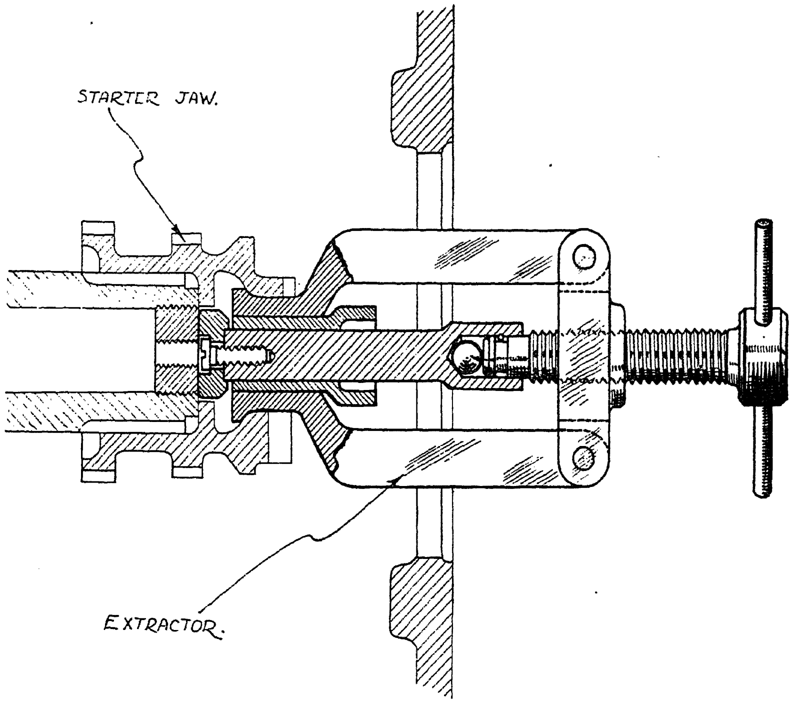


Fig. 4.—DISMANTLING STARTER JAW FROM REAR END OF CRANKSHAFT TAIL SHAFT.

in end of cross-drive shaft and remove bolt. Next withdraw fuel pump coupling from cross-drive shaft followed by oil retainer flange.

When dual fuel pump is fitted direct to rear cover, remove securing nuts and withdraw pump from studs. The oil retainer flange and coupling are not fitted in this instance as the dual pump is driven direct from the end of the cross-drive shaft.

At this stage it will be convenient to withdraw the cross-drive shaft complete with its housing from the rear cover. On later engines a laminated brass shim is interposed between housing and rear cover, and it is advisable to retain this shim on the studs by means of one or two nuts to prevent loss or damage. To dismantle the cross-drive shaft, release tabwasher securing shaft end nut, unscrew nut and withdraw tachometer driving gear. When single fuel pump or blanking cover is fitted direct to rear cover, unscrew the oil thrower which takes the place of a shaft nut. The shaft may now be tapped carefully out of its ball bearing. To extract ball bearing, remove spring retaining ring and lightly and evenly tap bearing out of housing.

Next remove starter jaw. Release tabwasher locking setscrew in

extreme end of tail shaft, remove setscrew and washer and withdraw starter jaw by means of extractor provided (Fig. 4).

Release tabwashers for nuts securing rear cover to volute casing studs and remove nuts. Detach rear cover unit from volute casing, taking care to withdraw steadily and evenly to avoid damaging the white-metalled rear bearing.

Unscrew the rear cover oil filter and detach filter from its cap.

The V.P. airscrew control valve should not be dismantled from the rear cover.

Rear Cover Auxiliaries and Auxiliary Drives

Rear cover auxiliaries such as automatic gun gear, rotoplunge oil pump, Romec vacuum pump, B.T.H. air compressor, R.A.E. air compressor or automatic boost control, should not be dismantled, but removed as a complete unit and returned to the makers in the event of rectification or replacements being required.

Automatic Boost Control. Unscrew securing nuts and remove boost control unit. Fit suitable blanking plate over connecting passages in rear cover to prevent ingress of foreign matter.

B.T.H. Air Compressor Drive. To dismantle drive when single fuel pump is used proceed as follows.

Release tabwashers of nuts securing compressor driven bevel bearing housing to compressor drive casing and withdraw housing complete with bevel. Turn back lockwasher, unscrew nut securing ball bearing to driven bevel and tap bevel gear out of bearing. Release tabwasher and unscrew bolt which retains the fuel pump coupling, meanwhile preventing rotation of compressor drive shaft with special tool provided. Withdraw coupling from serrations in shaft followed by oil retainer flange and oil thrower. Next release lockwasher and unscrew bearing retaining nut at other end of driving shaft, again using special tool to prevent rotation of shaft. Extract spring retaining ring from groove in compressor drive casing and tap shaft, complete with both ball bearings, out of casing from the outer end. Remove the circlip from its groove in the shaft and tap off both ball bearings.

When a dual fuel pump is used, the procedure is similar to that described above except that neither fuel pump coupling, oil thrower nor oil retainer flange are fitted.

Single and Dual Fuel Pumps. The procedure for dismantling the single or dual fuel pump is not given, as it is strongly recommended that the unit concerned be returned to the manufacturers when adjustment or reconditioning becomes necessary.

Auxiliary Drive Shaft and Gun Gear Shaft. Unscrew nuts securing end cover and remove cover. Withdraw bearing housing from ball bearing on shaft. Remove bolts securing generator drive casing to adaptor and withdraw casing complete with auxiliary drive shaft. To

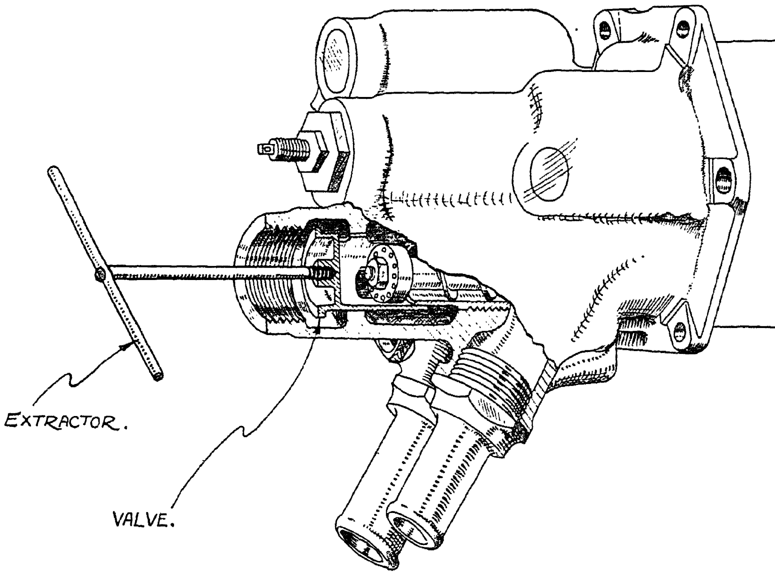


Fig. 5.—EXTRACTING HIGH INITIAL OIL PRESSURE DEVICE VALVE FROM OIL PUMP BODY.

dismantle shaft from casing, release tabwasher, unscrew shaft nut and tap shaft out of ball bearing. Draw generator driving bevel off shaft and remove key, followed by distance piece. Extract spring retaining ring and tap auxiliary shaft out of casing complete with inner ball bearing.

Remove securing nuts and detach auxiliary drive casing with gun gear shaft from rear cover. On later engines it will be found that one of the securing nuts is inside the auxiliary drive casing and is locked by a tab-washer. To remove gun gear shaft, withdraw split pin and unscrew shaft nut after which shaft may be tapped through its plain bearing and out of auxiliary drive pinion to which it is keyed.

Rotoplunge Oil Pump Drive. Take off nuts and withdraw adaptor and drive unit from their housing in rear cover. Next withdraw pump driving spindle from the hollow drive shaft. Secure drive shaft firmly, using the jig provided in the tool kit, release tabwasher, unscrew shaft nut and remove washer, distance piece and oil retainer. Next tap drive shaft out of its ball bearings. To dismantle bearings from housing, remove retaining ring and tap out one bearing. Invert housing and tap out the other bearing.

Romec Vacuum Pump Drive. To dismantle the Romec pump drive, remove nuts and withdraw drive housing from auxiliary drive casing, Release lockwasher under drive shaft nut, unscrew nut and tap shaft out of ball bearings. Remove the lower ball bearing retaining ring and tap out bearing from housing using suitable soft alloy drift. The blows

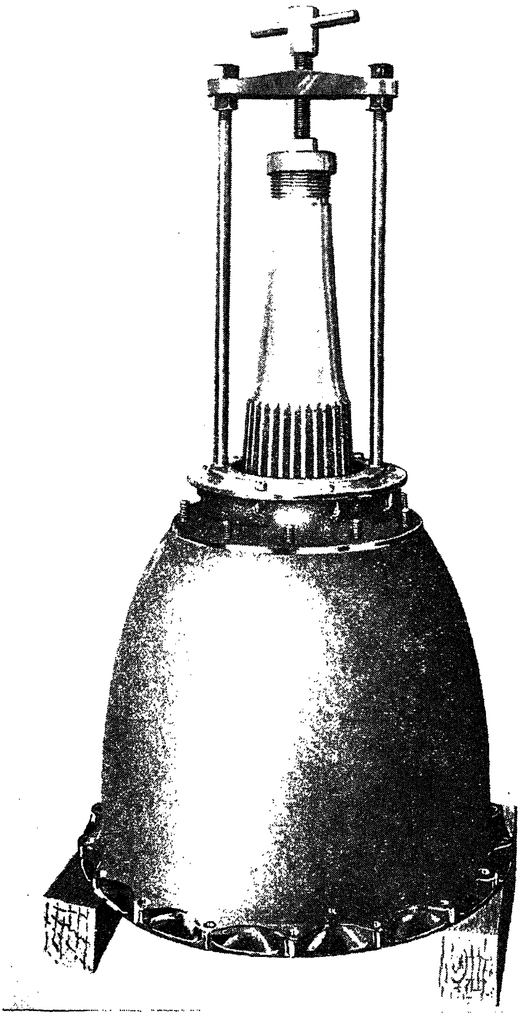


Fig. 6.—WITHDRAWING OIL TRANSFER HOUSING FROM REDUCTION GEAR CASING.

will be directed on to the bearing from an angle, the central distance piece being moved slightly to one side. Next invert housing and tap out upper bearing.

R.A.E. Type Air Compressor Drive. Release tabwashers, unscrew nuts and withdraw drive housing complete with bevel gear from auxiliary drive casing. Turn back tab of lockwasher under bevel gear shaft nut and unscrew nut, meanwhile holding gear firmly in jig provided. Remove bearing retaining flange, tap out bevel gear from ball bearing and finally bearing from housing.

Cardan Shaft Type Generator Drive. The generator will have been disconnected from drive prior to removal of engine from airframe. To dismantle drive, first remove hinged cover and generator drive housing, then remove nuts, bolts and washers securing flexible coupling disc to laminated spring coupling shaft and to cardan shaft and withdraw coupling shaft. Remove bolts securing upper flexible coupling disc to universal shaft driving members and to cardan shaft and detach cardan shaft. Next remove the four nuts retaining bearing housing to generator drive casing and withdraw driven bevel unit complete which comprises

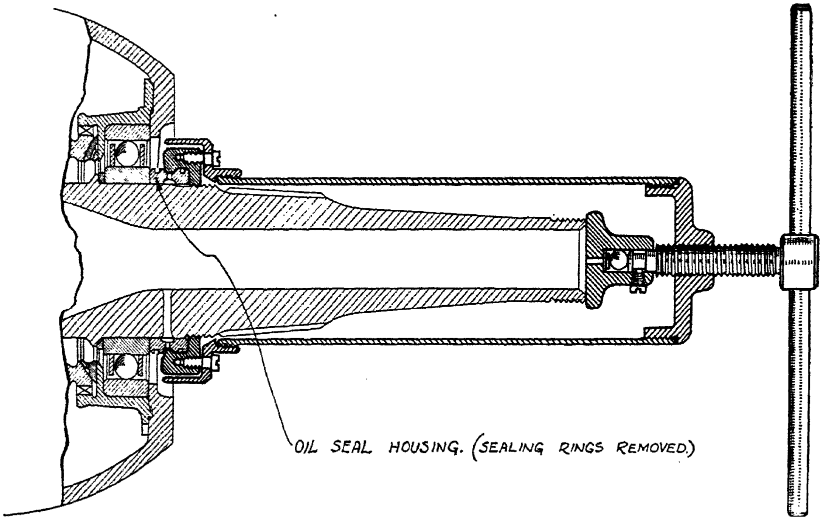


Fig. 7.—WITHDRAWING OIL SEAL HOUSING FROM AIRSCREW SHAFT.

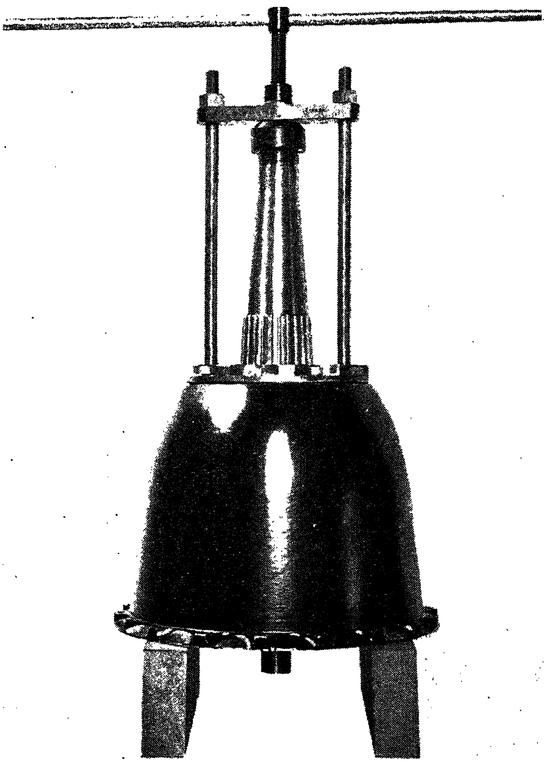
universal shaft, bearing housing, dished oil thrower, ball bearing, distance pieces, roller bearing, oil thrower, laminated shim and driven bevel. Remove split pin, unscrew retaining nut and withdraw shaft from driven bevel. The driven bevel may now be tapped out.

Flexible Type Generator Drive. Unscrew the four nuts which secure generator drive housing to housing cover and remove housing. Remove locking wire and unscrew knurled collar nut securing flexible drive and casing to flexible drive housing and withdraw drive complete. Take off the four nuts and remove drive housing from generator drive casing. To remove driven bevel, release lockwasher, unscrew locking nut and tap out bevel into generator drive casing. Tap roller and ball bearings out of casing from inside together with distance pieces, oil thrower and laminated shim.

Oil Pump

Before removing nuts retaining oil pump to rear cover, remove relief valve cap complete with adjusting screw, lock nut and unbroken seal. Withdraw relief valve and spring from pump.

Remove the high initial oil pressure device sprayer cap, take out valve spring bridge, spring, and valve. This valve is provided with an internal thread in a central boss for extraction purposes, and the extractor provided should be used (Fig. 5). Remove nuts and withdraw oil pump from rear cover, using extractor provided. Withdraw split pins, remove nuts securing pressure pump casing to scavenge pump casing, remove check valve bridge piece, check valve with spring, retaining plate and



8.—WITHDRAWING REDUCTION GEARCASE FROM REDUCTION GEAR UNIT.

pump cover. Separate pressure pump casing from scavenge pump casing and remove gears from both. Withdraw driving gear spindle from pump cover.

Magneto Drive

Release lockwashers under nuts securing the two magneto bevel housings and dismantle housings complete with driving drums and laminated shims. Withdraw split pins and remove nuts securing driven bevel gears to driving drums and separate the two components. Release lockwasher under nut securing magneto spring drive gear spindle and washer, remove nut and washer from spindle and withdraw magneto spring drive gear. Remove setscrews securing spring drive gear centre and dismantle centre springs and bevel gear from drive gear. Take off the two nuts and tabwashers retaining the drive spindle inside the rear cover and withdraw the spindle.

Reduction Gear Unit

0·5 : 1, 0·572 : 1 *and* 0 666 : 1 *Ratios.* Remove nuts securing reduction gear casing to crankcase studs and withdraw gear unit complete from crankcase, care being exercised to avoid damaging bore of airscrew shaft bush in front half crankshaft. Support unit on blocks of sufficient height to clear tail shaft, or, alternatively, allow tail shaft to enter a hole in the bench.

At the appropriate stages in dismantling the unit ascertain whether the reduction gear driving wheel, rear bevel gear, front bevel gear, bevel pinions and stationary gears are punch marked. If not, the bevel gears

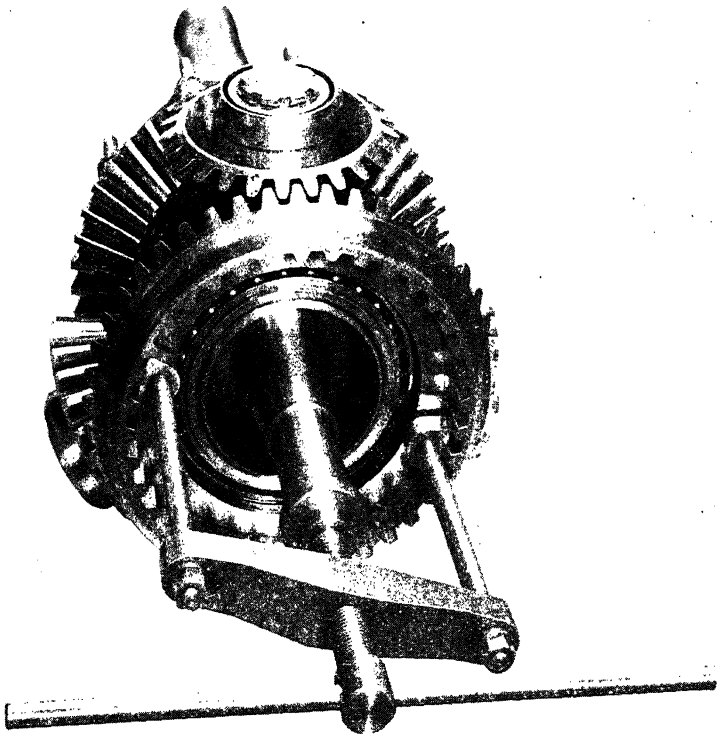


Fig. 9.—DISMANTLING REAR BEVEL GEAR COMPLETE WITH REAR THRUST RING AND BEARING.

are to be lightly punch marked on the face of one parallel tooth and stationary gear and reduction gear driving wheel on the face of two adjacent parallel teeth.

Remove nuts securing oil retainer to oil transfer housing, withdraw oil retainer and cover, also felt washer immediately behind it. Release lockwasher securing the left-hand threaded airscrew thrust nut and remove nut using spanner provided. Remove washer together with oil thrower. Remove nuts securing oil transfer housing to reduction gear case, and mark position of housing relative to case to ensure correct reassembly. Next withdraw oil transfer housing complete from reduction gear casing employing extractor (Fig. 6), after which withdraw oil seal housing from airscrew shaft using the appropriate extractor (Fig. 7). Assemble extractor (Fig. 8) to gearcase studs using stud nuts. Turn tommy bar in clockwise direction until airscrew shaft is free from front bearing, and withdraw reduction gear. Withdraw front gear and spherical ring, then, with a light alloy drift, tap out stationary gear together with ball bearing from case; remove bearing from stationary gear. Bend back tab of

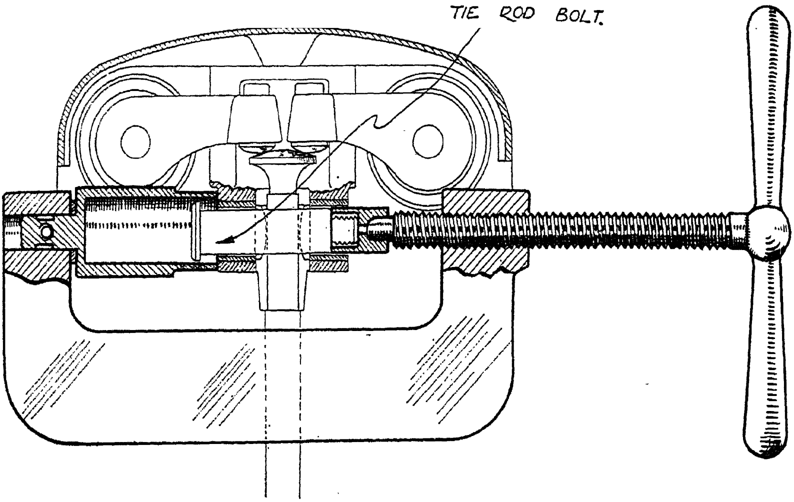


Fig. 10.—EXTRACTING TIE ROD BOLT FROM FRONT END OF ROCKER BRACKET.

airscrew shaft rear locknut washer and remove nut, which has a left-hand thread, using spanner provided. Withdraw rear bevel gear, together with rear thrust ring and thrust bearing using extractor (see Fig. 9). Release lockwashers retaining pinion journal nuts and remove thrust bearings. Withdraw bevel pinions together with pinion bushes, care being taken not to damage the white metal.

Push Rods and Tie Rods

Lift and turn spring locking plates on each rocker cover, remove setscrews and detach covers. Rotate crankshaft until all valves in the cylinder being worked upon are closed. Unscrew rocker adjusting screws several turns. Release lockwasher, unscrew tie rod bolt nut and remove bolt, using extractor (Fig. 10). Swing rocker bracket upward to clear push rod upper ends and simultaneously withdraw push rod heads. Release tabwashers under nuts securing tie rod base, remove nuts and withdraw push rod unit complete. Slide off the push rod cover tube and dismantle push rods from tie rod.

Similarly remove the remaining push rod units.

Front Cover

Release lockwasher under reduction gear driving wheel nut and unscrew nut, which has a left-hand thread. Withdraw driving wheel from crankshaft using extractor provided (Fig. 11). Release lockwasher under crankshaft bearing thrust nut, unscrew nut *and remove lockwasher*. Withdraw front cover complete with ball bearing and layshaft assembly using extractor.

Upon withdrawal of front cover, ascertain whether there are one or two centralising shims between front cover bearing inner race and the serrated cam drive gear. These must be isolated to the engine on which they are fitted.

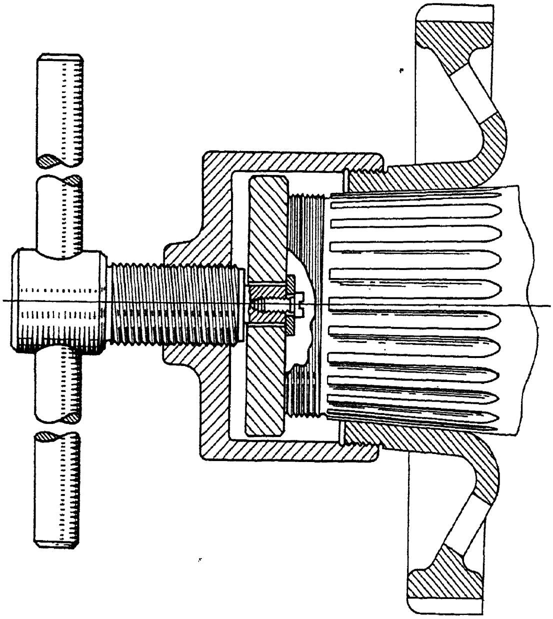


Fig. 11.—WITHDRAWING REDUCTION GEAR DRIVING WHEEL FROM FRONT END OF CRANKSHAFT.

Cam Gear Layshaft. To dismantle layshaft release lockwasher and remove layshaft nut preventing rotation of shaft by employing holder provided in tool kit. Release lockwashers and unscrew nuts securing rear layshaft roller bearing housing to front cover. Tap out layshaft from front end, using a suitable soft metal drift to protect shaft threads, and withdraw the unit. The front and rear bearings are not to be removed unless replacement is found necessary.

Remove retaining ring locating crankshaft front ball bearing and tap bearing out of front cover with soft aluminium drift.

Cam and Tappet Gear

Tappets and Guides. Withdraw guides complete with tappets and rollers. To loosen guides employ a tapered length of soft alloy bar, and exert light leverage at bottom of guide using a cam lobe as fulcrum point. Exercise great care during this operation and on no account lever from tappet guide locating ring. This should be sufficient to break rubber joint seal, when guide may then be removed by hand.

Cam Assembly. Slide serrated cam drive gear off crankshaft and remove cam sleeve together with crankshaft sleeve employing extractor and adaptors provided (see Fig. 12). Remove crankshaft sleeve key by screwing a 2 B.A. × 31·4 threads per inch setscrew down through tapped hole in centre of key.

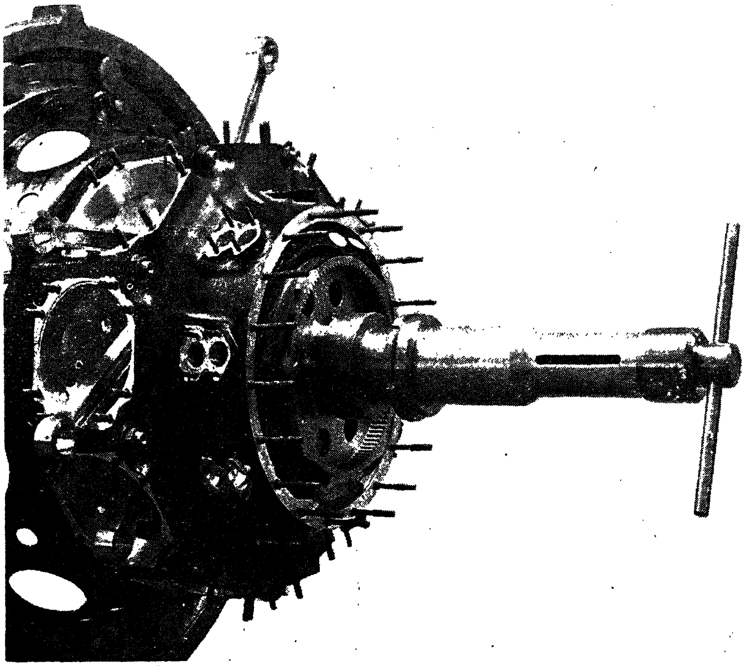


Fig. 12.—DISMANTLING CAM SLEEVE TOGETHER WITH CRANKSHAFT SLEEVE FROM CRANKSHAFT FRONT END.

Oil Sump

Release lockwashers, remove stud nuts and set bolts securing sump to crankcase and withdraw sump complete.

Cylinders, Pistons and Induction Branch Elbows

Remove cylinders in the following order : Nos. 3, 1, 8, 4, 9, 2, 7, 5, 6.

Unscrew nuts securing inlet pipe holders to inlet pipe branch and disconnect the three priming pipes on cylinders Nos. 9, 1 and 2 from the main pipes.

Turn engine on stand until No. 3 cylinder is in a horizontal plane on the right-hand side of engine (looking on front). Lock engine stand in this position by means of clamp. Release lockwashers and remove cylinder retaining nuts using the appropriate spanners. Rotate crankshaft until master spline on crankshaft is in line with cylinder being removed ; this will place piston of cylinder concerned on top centre. Adopt this procedure when removing each cylinder. Rock cylinder slightly to break rubber joint seal and withdraw from crankcase. Support piston by hand to prevent damage to piston and crankcase on withdrawal of cylinder. Assemble the protector plates to crankcase cylinder studs.

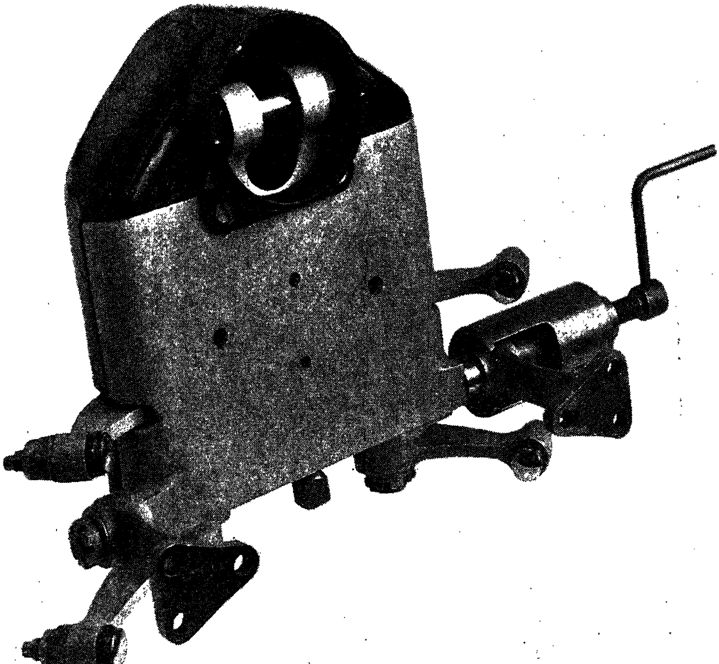


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Fig. 13.—DISMANTLING CYLINDER LUGS FROM ROCKER BRACKET TRUNNION ARMS.

Remove gudgeon pin circlip, using special pliers provided, and take off gudgeon pin ring. Push out gudgeon pin and remove piston ; take off the piston rings. Piston rings once removed should not be used again. Remove nuts and H.T. wire support clips from studs securing induction branch elbows to cylinders. Remove nuts and dismantle inlet pipes together with inlet pipe joint ring. Similarly remove remaining cylinders in the order stated.

Valves and Rocker Gear

Valves. Position cylinder over a circular wooden dolly suitably shaped to fit the pent house roof of cylinder head. Compress the inlet and exhaust valve springs, using the respective compressing tools provided, and remove split cotters. The valve spring upper washers must not be tapped with a hammer to loosen cotters as this practice invariably leads to damage of valve stem. The procedure for dismantling valves of later engines differs owing to felt lubricating pads being fitted in the upper washers. First remove circlip from groove in each valve upper washer, then extract retaining plate and felt pad. The springs may now be compressed, using the appropriate tools, and the split cotters removed.

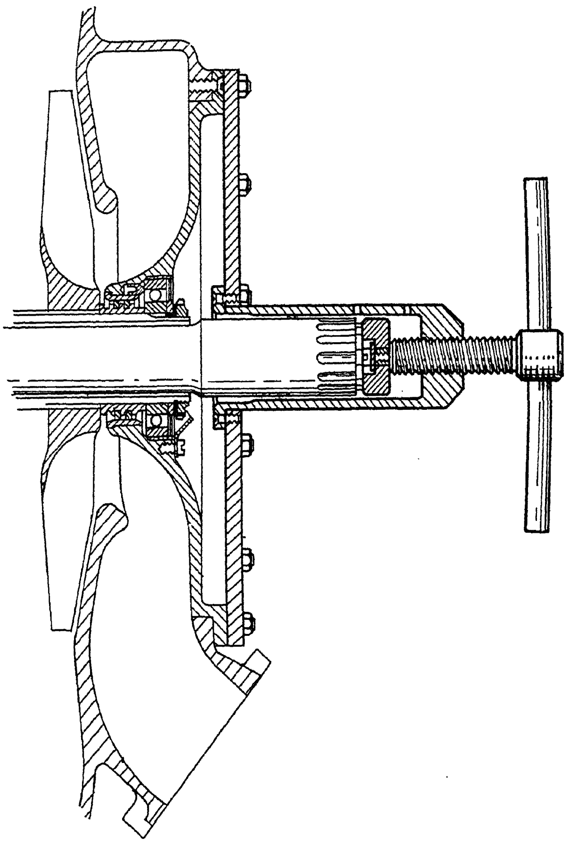


Fig. 14.—WITHDRAWING SUPERCHARGER UNIT COMPLETE REAR OF ENGINE.

The spring compressing tools supplied with later engines differ from those used on earlier engines, owing to the upper washer felt pads.

After withdrawing valves release lockwasher and remove nuts securing cylinder lugs. Remove rocker unit complete with lugs from cylinder head.

Rocker Units. Remove split pins and unscrew nuts securing cylinder lugs. Withdraw cylinder lugs from rocker bracket trunnion arms using extractor provided (Fig. 13). Take out split pins and remove nuts securing the right and left-hand inlet rocker arms. Unscrew plug from inlet rocker shaft bore. Dismantle inlet rocker arms and shafts simultaneously, employing extractor. Carefully relieve peened metal on each side of screw slots securing the grease retaining cap and remove screws, caps, grease retainers, springs and washers. Dismantle the right and left-hand exhaust rockers from rocker brackets and remove cork grease retainers. Tap ball bearings from rocker brackets using a soft metal drift, and similarly remove ball bearings from exhaust rockers. Dismantle remaining rocker units in similar manner.

Supercharger

Remove setscrew and nuts securing each inlet pipe branch to volute casing and remove branches. Release lockwashers and remove nuts on rear end of crankcase bolts which secure supercharger unit. Withdraw

unit complete, using extractor provided (Fig. 14). Bend back both tabs of lockwasher and remove nut securing spring drive gear to crankshaft. Withdraw spring drive gear employing extractor provided. Before stripping spring drive gear unit scribe a line across rear spring drive plate, spring drive centre and gear, and also mark front side plate on same centre line. To dismantle spring drive gear, carefully relieve peening of spring drive gear bolts by means of a $\frac{3}{16}$-in. diameter drill; then remove bolts and plates. Press out springs and pads from gear unit and detach centre.

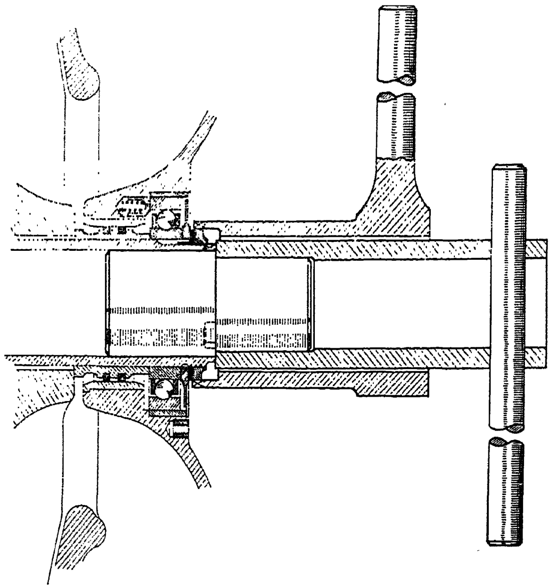


Fig. 15.—SHOWING APPLICATION OF BOTH SPANNERS REMOVAL OF IMPELLOR SHAFT NUT.

Slacken nuts securing volute casing to blower casing; these components are separated later. Remove impellor bearing oil trough, after which release lockwasher and unscrew impellor shaft nut, using the special spanners as illustrated in Fig. 15.

Position unit with rear face uppermost and supported on the appropriate fixture, which is designed to support front impellor shaft ball-bearing housing when tapping out impellor gear. Tap rear end of impellor gear, using suitable soft metal drift, and take off front oil thrower.

Remove rear oil thrower, impellor rear ball bearing, spring pads and springs from their housings in volute casing cover. The rear oil seals can now be withdrawn. Remove securing nuts, dismantle volute casing from blower casing and remove impellor. Take out retaining ring, carefully tap out front impellor ball bearing and remove front oil seal from behind bearing. Turn back tabs of lockwashers and unscrew nuts securing intermediate bearing support ring; withdraw ring using extractor. Slide intermediate gear units complete off their respective bearing rollers. Care must be taken to segregate rollers and races with their particular gears, and to this end it is advisable to place the units in suitable containers.

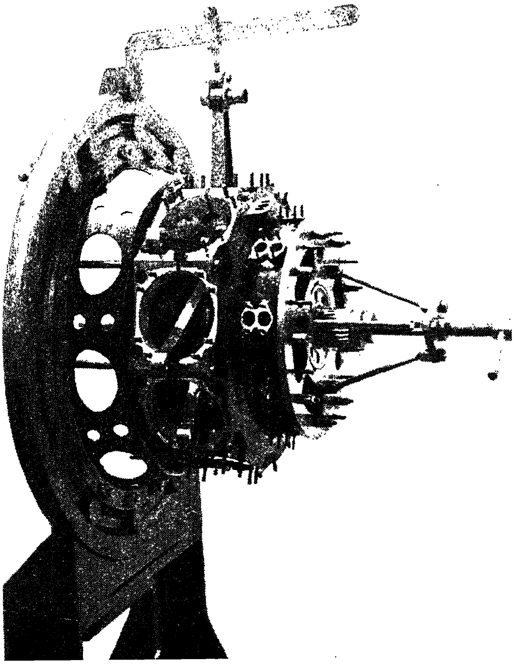


Fig. 16.—WITHDRAWING CRANKCASE FRONT HALF.

To dismantle intermediate gear, release lockwasher and remove pinion nut, meanwhile securing pinion with holder provided. File bolt and nut end faces of all bolts to relieve peening, remove nuts and dismantle side plates, clutch blocks and intermediate gear from gear centre. Press out intermediate gear pinion from gear centre.

On later engines the gear centre and pinion are to be considered a unit, since the pinion nut is locked by peening; no attempt should be made to loosen pinion nut.

Front Half Crankcase

Position master rod vertically and attach it to jib on engine stand using a substitute gudgeon pin. Carefully adjust shackle to take weight of assembly; correct alignment is essential.

Release lockwashers and unscrew front crankcase bolt nuts, using spanner provided. Remove protector plates from cylinder holding down studs and insert the tool jack between crankshaft balance weights to counteract end load imposed when front half crankcase is removed.

Fit the distance pieces supplied with extractor on to six equally spaced front cover studs on crankcase and assemble extractor plate and steady sleeve (see Fig. 16). During withdrawal, ensure that front half crankcase is square with all its bolts and exercise every care to prevent damage to crankshaft as the combined weight of extractor and case is considerable. The front bearing rollers will be displaced on partial withdrawal of case and should be caught in a suitable tray.

Crankshaft and Connecting Rod Assembly

Crankshaft. Before withdrawing crankshaft and connecting rod

assembly from rear half crankcase, check adjustment of shackle to ensure smoothness of travel, as, should the shaft be out of alignment through maladjustment of jib, difficulty will be experienced due to binding of main roller race. Steady crankshaft at front end, and withdraw the assembly; during this operation the rear rollers will be displaced and should therefore be caught as previously described for front rollers.

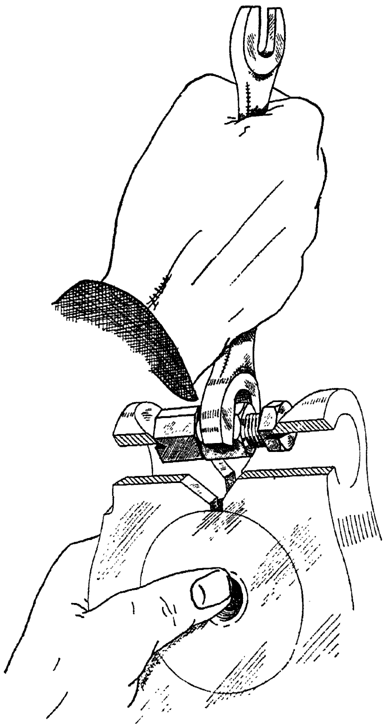


Fig. 17.—SHOWING APPLICATION OF EXPANDING TOOL IN THE "VEE" OF REAR HALF CRANKSHAFT.

Remove assembly from jib and place in vice or special fixture; if a vice is used, provision must be made to support the crankshaft in addition to protecting it against damage by the vice jaws. Release lockwashers and remove front and rear crankpin oil plugs using the appropriate spanners provided; take off lockwashers. Take out split pin, remove maneton bolt nut, using the special spanner, and withdraw bolt. Take assembly out of fixture or vice and place on bench. Next insert the expander into the "vee" of rear half crankshaft as shown in Fig. 17, and expand the "vee" slot sufficiently to permit free withdrawal of rear half. In no circumstances may the slot be expanded more than 0·015 in.

Dismantle rear half crankshaft from front half and remove expander. Withdraw connecting rod assembly from crankpin, taking great care to avoid damaging the floating bush which must be withdrawn with the connecting rod assembly. Release lockwasher and remove setscrew locking oil plug in web of rear half crankshaft. Next unscrew oil plug, using spanner provided. Remove spring, packing sleeve, and felt packing ring from crankshaft. Remove spring ring and distance piece securing crankshaft tail shaft and withdraw the latter.

Remove oil sleeve circlip in tail shaft with pliers provided and withdraw sleeve using extractor. Remove oil plug in front half crankshaft in same manner as described for rear half crankshaft oil plug.

Connecting Rod Assembly. Withdraw floating bush and remove rear oil retainer complete with plungers and springs. Hold connecting rod assembly firmly in a vice by means of master rod, using suitably shaped

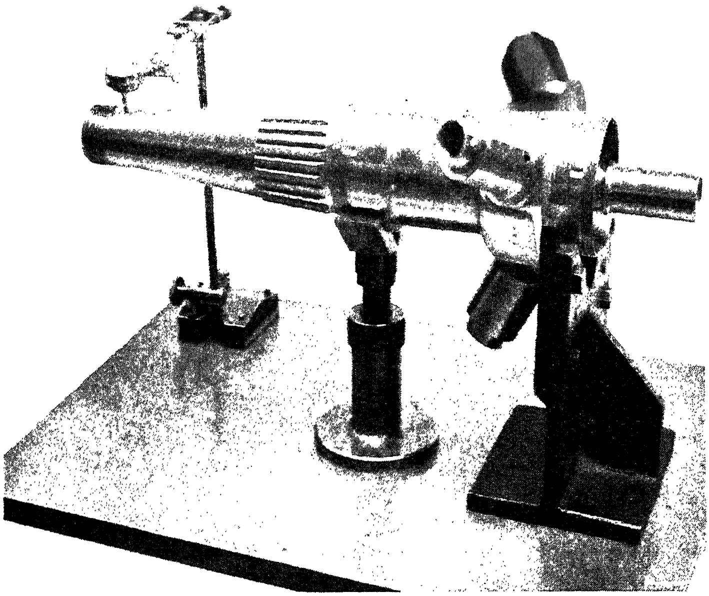


Fig. 18.—CHECKING ALIGNMENT AND CONCENTRICITY OF AIRSCREW SHAFT.

hard wood blocks located in the channel section of the rod. Withdraw split pins and unscrew wrist pin bolt nuts. Use box spanner on bolt heads to prevent bolts turning during this operation. Remove front oil retainer complete with locating bush and take out wrist pin bolts. Support each articulated rod in turn and drive out its wrist pin from front end, using special drift provided in tool kit.

Rear Half Crankcase

Remove crankcase bolts, using suitable drift, and dismantle rear half crankcase from cone mounting. Remove cone mounting from engine stand and when such are fitted remove flexible mounting units complete.

INSPECTION AND REPLACEMENTS

Before cleaning, all components should be generally examined for signs of scoring, burning or other unsatisfactory conditions, as a defect is sometimes more readily apparent when the oil or loosened surface of metal is present than after the part has been washed.

After a thorough washing in clean petrol or paraffin the components should be laid out and subjected to a detailed inspection. Light running scores or fret marks may be removed by careful stoning, using a fine-grade stone. Ball bearings should be spun by hand, and where any

harshness of movement is present a complete new bearing should be fitted.

The following notes should be read in conjunction with the "Fits and Clearance" Schedule (see end of article), and where necessary additional dimensional checks are to be made against the tolerances specified therein. Parts which fail to conform to the limits given must be replaced by new ones.

For details of the etching and Magna-Flux processes application should be made to the manufacturers.

Particular attention should be paid to the following :—

Reduction Gear

If the aeroplane has been involved in an accident the airscrew shaft should be mounted in "vee" blocks and checked for alignment (see Fig. 18). In the event of malalignment, return shaft to makers. Etch or Magna-Flux test the splines. Chalk test pinion bushes by immersing in hot paraffin (temperature 100° C.) for fifteen minutes, after which dry thoroughly and dust surfaces evenly with french chalk. Examine after about one hour, when minute cracks or adhesion failure of white metal will be indicated by discoloration due to exuding oil. Magna-Flux test pinion bores and stone teeth where necessary. Check stub arm diameters, pinion bush

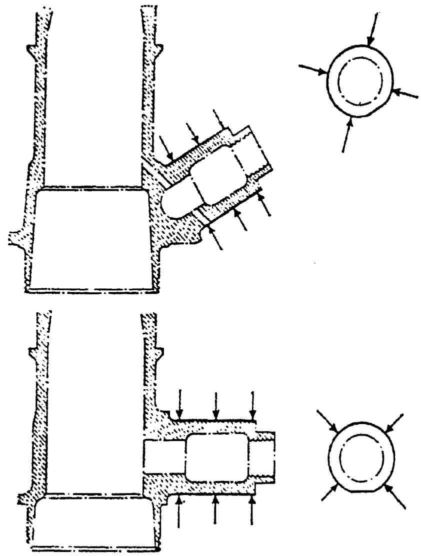


Fig. 19.

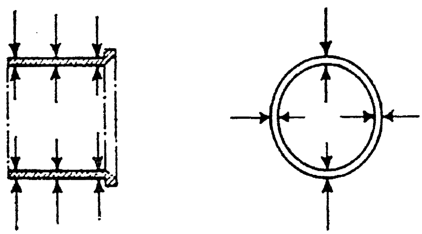


Fig. 20.

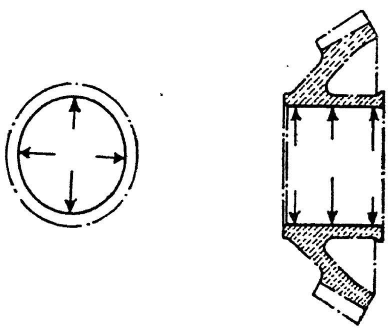


Fig 21.

Figs. 19, 20, 21.—CHECKING STUB ARM DIAMETERS, BEVEL PINION BUSH DIAMETERS AND BEVEL PINION BORES.

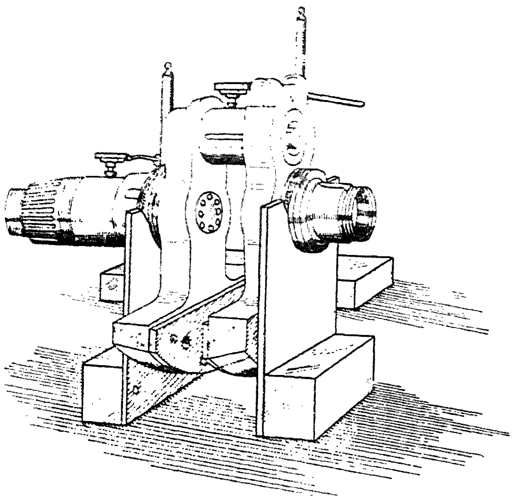


Fig. 22.—CHECKING FRONT BALL BEARING JOURNAL FOR CONCENTRICITY AND CRANKPIN FOR PARALLELISM AND TWIST USING DIAL INDICATORS.

diameters and pinion bores (see Figs. 19, 20 and 21). Observe ball bearing housing in front stationary gear for signs of creep. Where necessary lap in spherical faces of bevel gear thrust rings, using Alundum powder. Examine transfer housing and ensure that liner has not rotated.

Supercharger

Magna-Flux test the following components: Impellor, impellor gear, intermediate gears, spring drive gear and spring drive centre.

Light scores on contact faces of clutch blocks and corresponding faces of side plates are to be rectified by lapping with oil; no abrasive compound of any description may be used.

Examine blower casing, volute casing and volute casing cover for flaws or cracks.

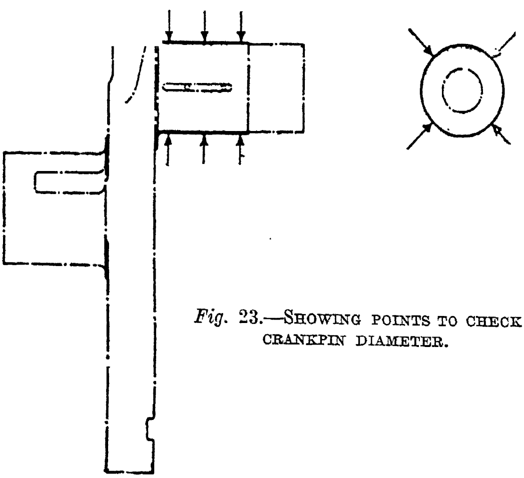


Fig. 23.—SHOWING POINTS TO CHECK CRANKPIN DIAMETER.

If replacement of front or rear ball bearing housings is necessary, return the casings to the engine makers.

Crankshaft

Magna-Flux test the taper splines. Assemble the two halves and mount crankshaft assembly on "vee" blocks. Check front ball bearing journal for concentricity, using dial indicator, and likewise check crank-

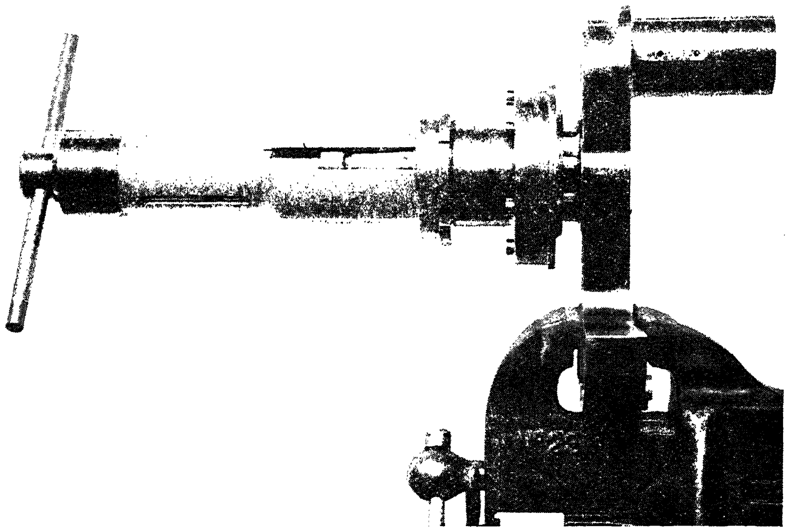


Fig. 24.—APPLICATION OF EXTRACTOR FOR WITHDRAWING FRONT INNER ROLLER RACE.

pin for parallelism and twist at two points through an angle of 90 degrees (see Fig. 22). Check crankpin diameters (Fig. 23). Oil pressure test tailshaft sleeve at 80 lbs. per square inch to ensure oil tightness.

Withdraw front bearing inner race for short distance, using extractor and adaptors (Fig. 24) and remove any sludge collected in annular space behind race ; also clean oil hole. If replacement of front or rear races is necessary they should be withdrawn, using the appropriate extractors (Fig. 24) and adaptors, and new races pressed on.

To replace airscrew shaft bush, extract bush, using extractor provided, and clean shaft bore. Apply clean oil to new bush and press in position, using insertor. Assemble the special jig to crankshaft and ream bush bore (Fig. 25). Finally check bore for size.

Connecting Rod Assembly

Master Rod. After careful visual inspection, check big end bore (Fig. 26), wrist pin bores and gudgeon pin bush bore for diameter (Fig. 27). Check master rod for parallelism and twist (see Figs. 28 and 29).

Finally Magna-Flux test for cracks.

Articulated Rods. Check bore sizes (Fig. 30) and check rods for parallelism and twist (see Figs. 31 and 32). Magna-Flux test for cracks.

Should replacement of bushes be necessary, return rods to makers or make application for instructions and details of special equipment required.

Big End Floating Bush. Thoroughly examine internally and externally for surface condition of white metal and chalk test as previously described for reduction gear pinion bushes. Check diameters (see Fig. 33).

Front Oil Retainer. To replace front oil retainer, proceed as follows :—

Assemble new component to master rod and secure in position with wrist pins, bolts and nuts. Place rod on surface plate, retainer uppermost, and check upper face of oil retainer (see Fig. 34). Lightly scrape face until indicator reading does not vary more than 0·001 in. around whole circumference. Check spherical seatings of wrist pin bolt nuts for

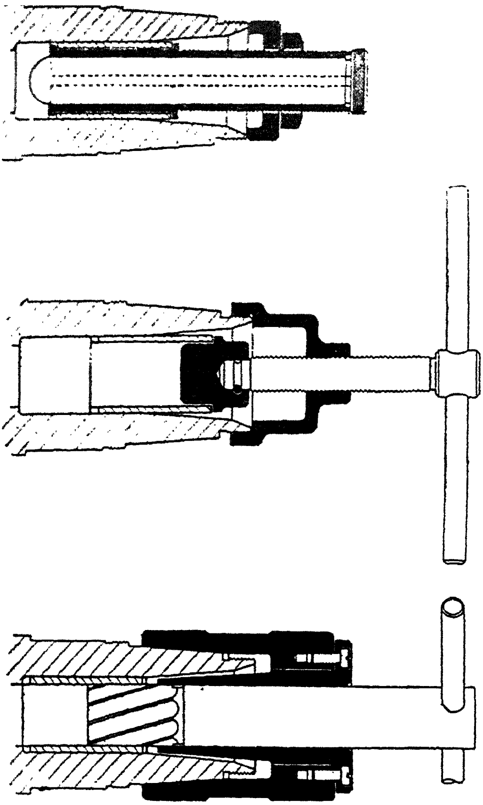


Fig. 25.—Application of tools for extracting, pressing in, and reaming airscrew shaft steady bush.

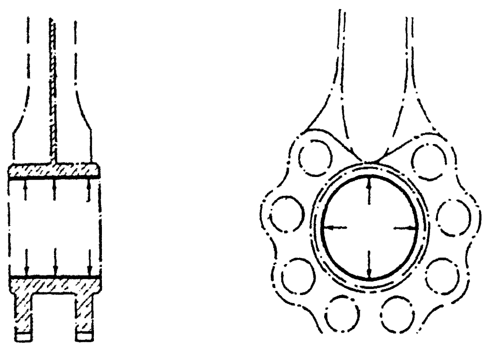


Fig. 26.—Showing points to check diameter of master connecting rod big end bore.

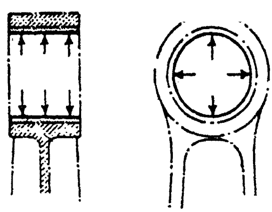


Fig. 27.—Showing points to check master rod gudgeon pin bush bore.

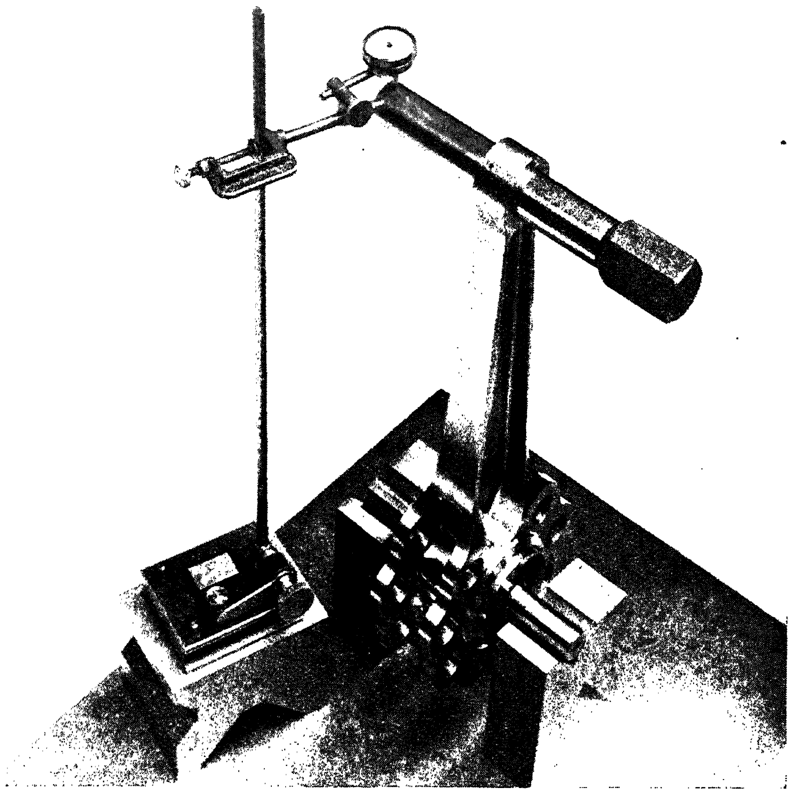


Fig. 28.—CHECKING MASTER ROD FOR PARALLELISM.

bedding with marking compound; 100 per cent. contact is required, and where necessary lap nuts to retainer, using fine abrasive.

Crankcase

Check that inner faces of main outer races are butting squarely against housing flange. If signs of malalignment are present or there is movement of race on application of hand pressure (after removal of retaining rings) remove race for further inspection. Before attempting to withdraw race, the crankcase must be dry-heated to approximately 150° C. in an oven. If slackness is not excessive an oversize race may be fitted in the existing housing, the crankcase being heated as for removal. If housings require replacement return crankcase to makers.

Examine crankcase walls and check spigot and joint faces. Check all studs for tightness and security and examine external threads for damage or overstressing. Inspect tappet guide locating ring for security.

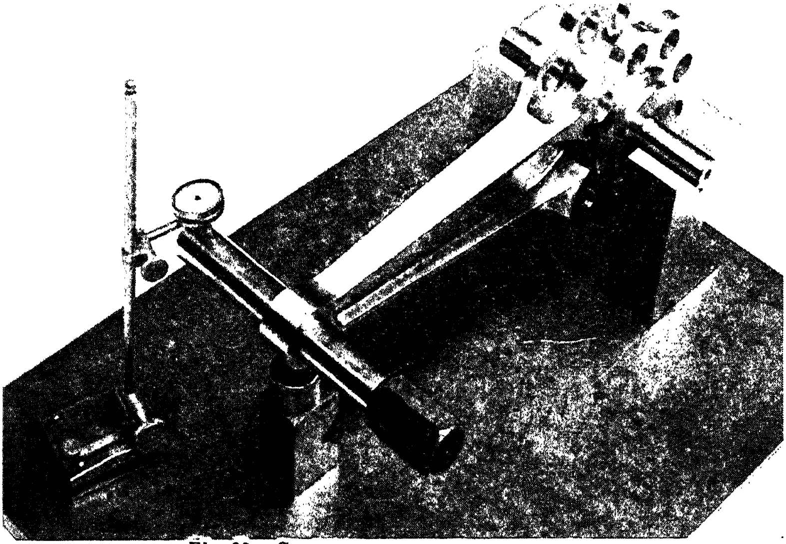


Fig. 29.—Checking master rod for twist.

Pistons and Rings

Chalk test the pistons and check the gudgeon pin bores and skirt diameters (see Fig. 35).

Piston rings once removed from their grooves must be replaced in every instance by new rings. Check the new rings for side clearance in their grooves, using feeler gauges. Make this check before assembling ring over piston, the ring being placed with its outside diameter in the groove.

Fit the two gas rings in the two top grooves; the rings must be assembled with the bevel uppermost, *i.e.*, towards piston crown. The third and fourth rings are oil scrapers, both being assembled in the third groove. The lower of these is scalloped and must be positioned with the scalloped face butting against its companion ring above. Both are fitted with the bevel uppermost.

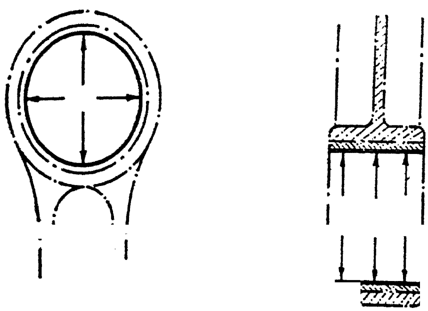


Fig. 30.—Showing points to check wrist pin and gudgeon pin bush bores.

In the case of No. 6 piston the two gas rings are identical with those of the other eight

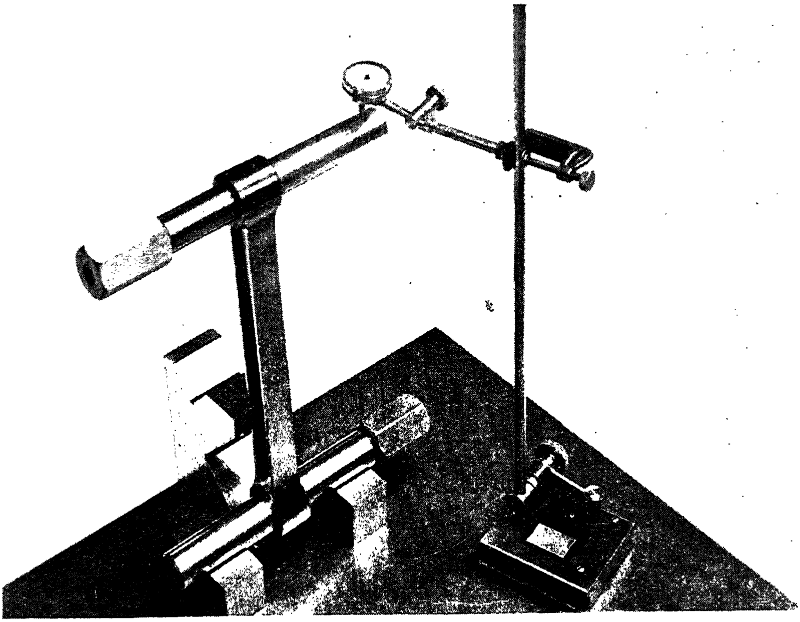


Fig. 31.—CHECKING ARTICULATED RODS FOR PARALLELISM.

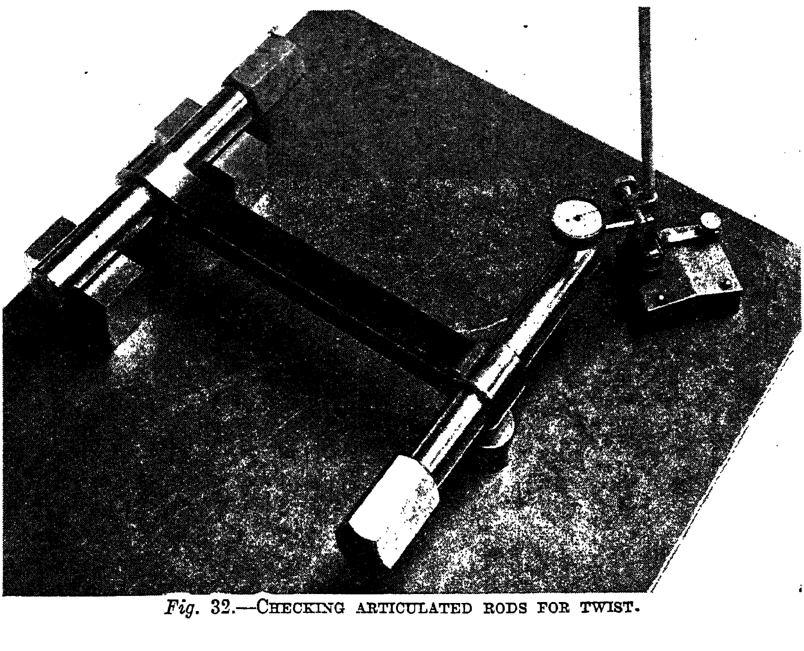


Fig. 32.—CHECKING ARTICULATED RODS FOR TWIST.

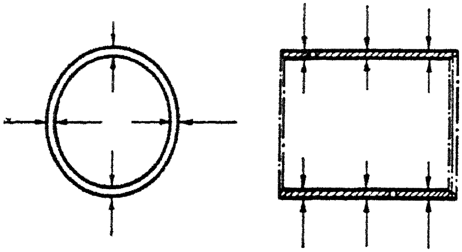


Fig. 33.—SHOWING POINTS TO CHECK INTERNAL AND EXTERNAL DIAMETERS OF BIG END FLOATING BUSH.

pistons. The upper scraper ring, however, is of U section, whilst the lower scraper ring is of rectangular section.

Rocker, Cylinder and Valve Assemblies

Inspection

Cylinders and Valves. Examine valve ports and guides for burning. Examine each cylinder bore and check diameter (see Fig. 36). Where valve guides do not conform to limits specified oversize components should be fitted. Inspect valves for corrosion and replace if excessive. Both inlet and exhaust valves are to be etched.

Examine taper faces and grooves in split cotters. Inspect valve springs for fracture ; check free lengths and pressure loads.

Rocker Units. Examine exhaust and inlet rockers and rocker bracket for general condition and test with Magna-Flux equipment.

Replacements

Tie Rod Bolt Bushes. Press out old bushes and fit new bushes, using the combined insertor and extractor tool (Fig. 37). Ream bush bores and check for size.

Rocker Trunnion Arm Bushes. Withdraw bushes, using extractor

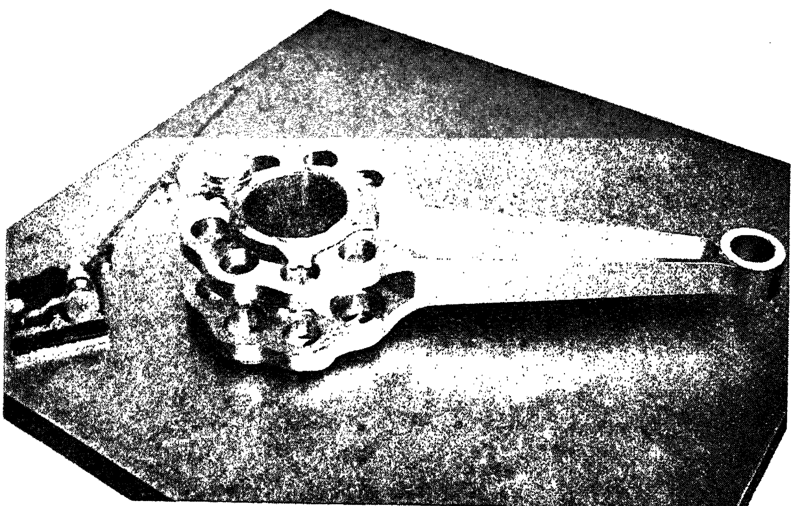


Fig. 34.—CHECKING FRONT OIL RETAINER FACE.

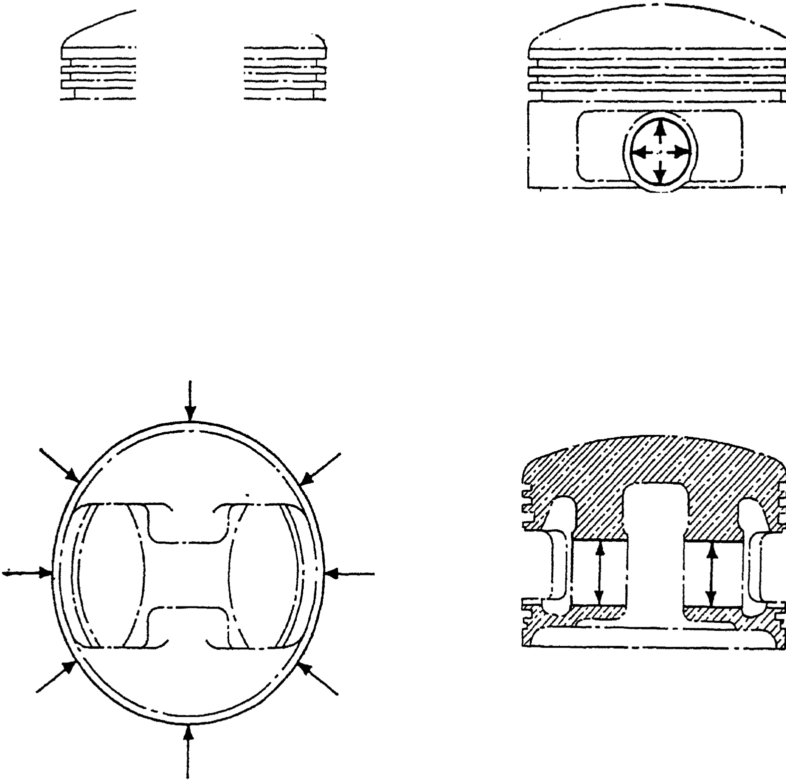


Fig. 35.—SHOWING POINTS TO CHECK PISTON SKIRT AND GUDGEON PIN BORES.

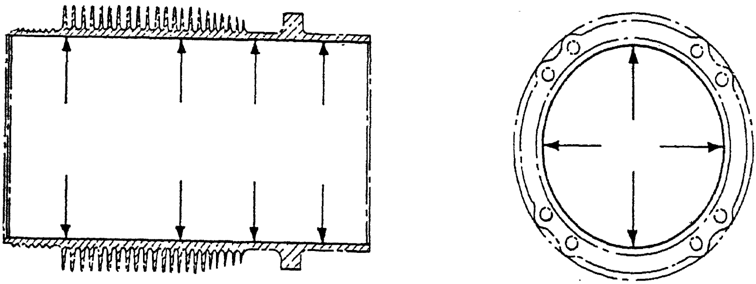


Fig. 36.—SHOWING POINTS TO CHECK DIAMETER OF CYLINDER BORE.

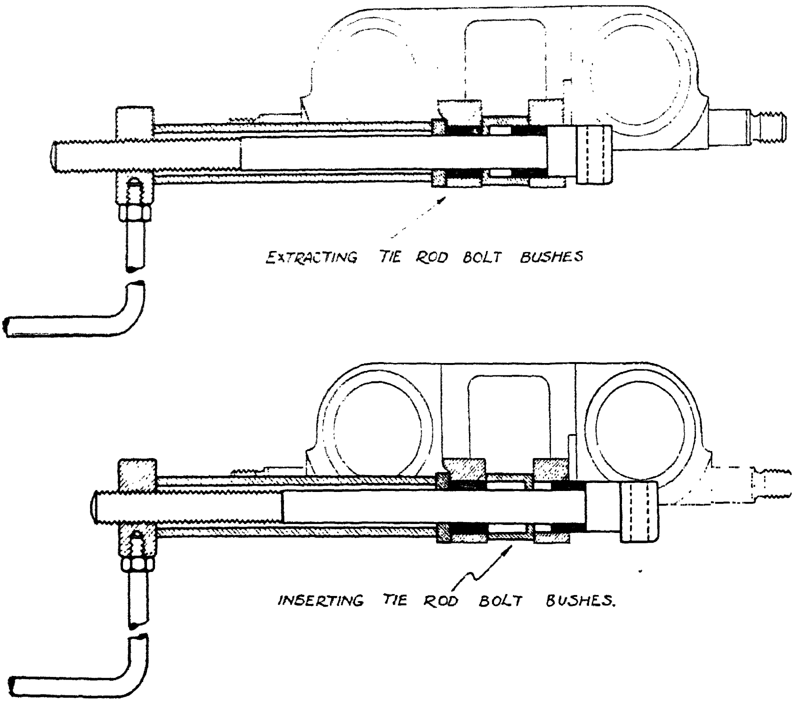


Fig. 37.—APPLICATION OF TOOL FOR INSERTING OR EXTRACTING TIE ROD BOLT BUSHES.

(see Fig. 38), and assemble new bushes with tool provided (see Fig. 39). Finally reduce outside diameter, using the special cutter.

Rocker Arm Bushes and Buttons. Withdraw bush complete with button, using extractor (see Fig. 40), and, using the same tool, insert new bush and button (see Figs. 41 and 42).

Valve Guides. Standard oversize components are to be fitted when replacement is required. Withdraw guide from cylinder head as shown in Fig. 43. Where necessary the guide bore in head is to be lightly reamed, and for this purpose a range of reamers is available to suit the various oversize guides. After reaming check bore for size, using the appropriate plug gauge.

When cleaning up the surface of the valve guide conical socket in the cylinder head it is particularly important that only the absolute minimum amount of metal be removed consistent with obtaining a true surface; this is essentially a cleaning up and not a recutting operation. A truing reamer, together with appropriate pilot bushes and angle gauges, is available.

Press in the oversize guide, using insertor (see Fig. 44). Place a lower valve spring washer in position and check clearance between underface

and cylinder head. Ream valve guide bores and check diameters, using reamers and gauges provided.

Valve Caps. Unduly worn valve caps should be replaced by new ones. Assemble valve stem cotters and withdraw old cap, using extractor (see Fig. 45). Tap new cap lightly and squarely into position with soft alloy drift.

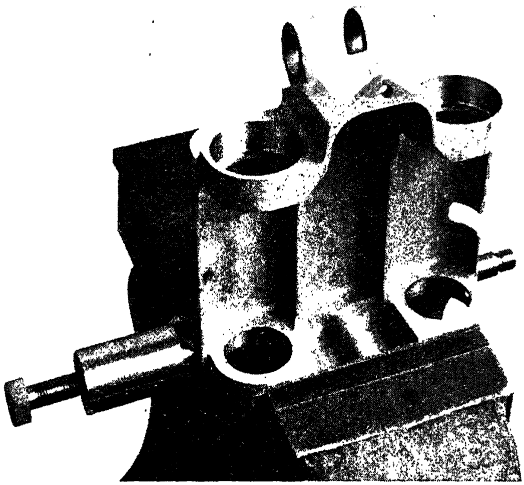


Fig. 38.—EXTRACTING ROCKER BRACKET TRUNNION ARM BUSHES.

Valves and Valve Seats. The seat faces of the valves may be reconditioned by machine grinding provided the head thickness is not reduced beyond the minimum specified. Use gauge.

Owing to the hardness of the nickel chrome manganese valve seats in the cylinder head, special grinding equipment is necessary for reconditioning, and application should be made to the engine manufacturers for detailed instructions.

Push Rods and Tie Rods. Inspect push rod upper and lower ends for wear. Examine push rod detachable heads, check stem diameters and Magna-Flux test. Check tie rod eye bores.

To replace push rod ends, first withdraw lower end,

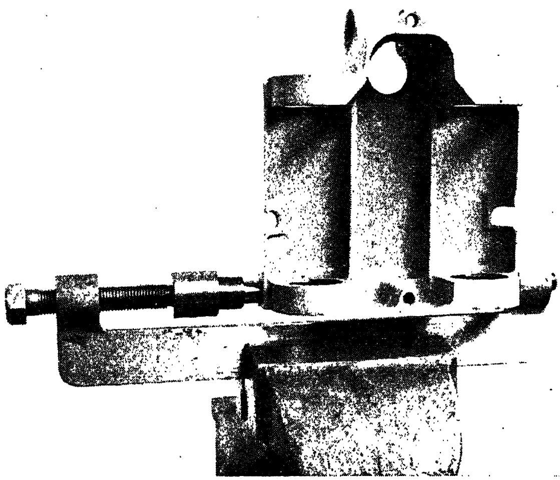


Fig. 39.—ASSEMBLY TOOL FOR ROCKER BRACKET TRUNNION ARM BUSHES.

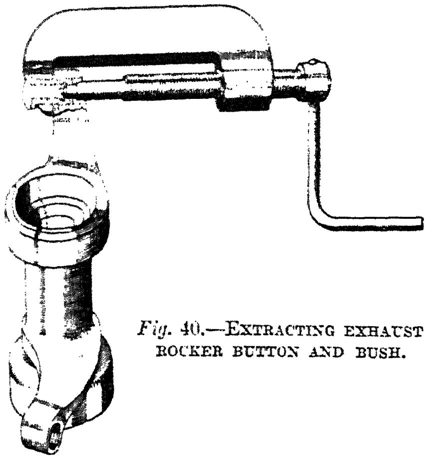


Fig. 40.—EXTRACTING EXHAUST ROCKER BUTTON AND BUSH.

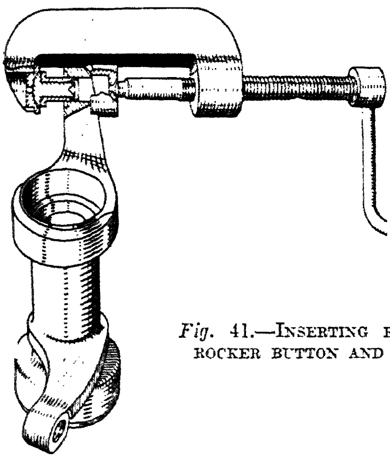


Fig. 41.—INSERTING EXHAUST ROCKER BUTTON AND BUSH.

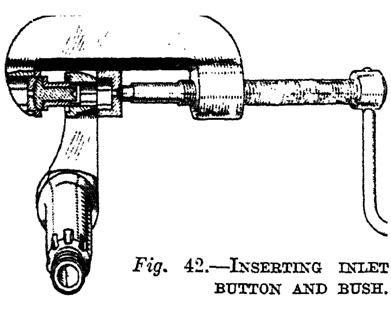


Fig. 42.—INSERTING INLET ROCKER BUTTON AND BUSH.

using extractor (see Fig. 46), then insert rod into bore of tube and tap out upper end. Tap new components into position, using suitable drifts.

Cam and Tappet Gear

Tappets and Guides. Examine tappet stems, rollers, roller pins and bushes and check fits and sizes where called for. Inspect " Gits " oil seals for fit and sealing efficiency. Replace if they fail to exert sufficient pressure to support weight of tappet. If replacement required, withdraw seal, using extractor (see Fig. 47), and gently tap new seal home in recess; it is important that the lettering on the case faces outward. Fit tappet assembly to guide, using tool provided (see Fig. 47). Ensure that oil seal lies below surface of guide flange outer face.

Inspect tappet guides and check bore diameters.

Cam Sleeve. Any light scores on cam tracks are to be removed by stoning and polishing. Check bores of cam sleeve bushes (Fig. 48). Inspect internal teeth and Magna-Flux test for cracks. Replacement of cam sleeve bushes entails return of sleeve to manufacturers.

Crankshaft Sleeve and

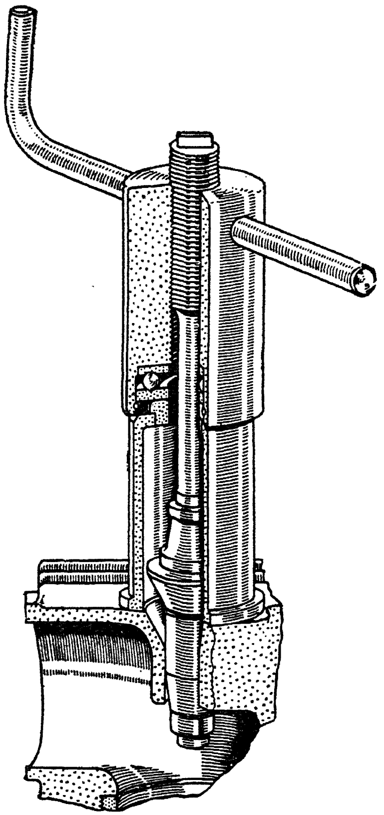


Fig. 43.—EXTRACTING VALVE GUIDE FROM CYLINDER HEAD.

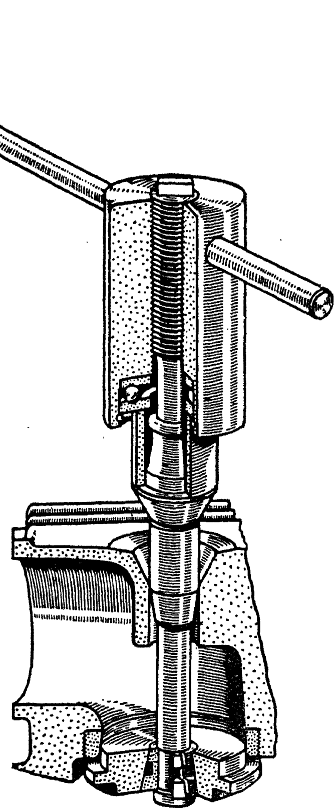


Fig. 44.—INSERTING OVERSIZE VALVE GUIDE INTO CYLINDER HEAD.

Cam Driving Gear. Ease any scores on tinned surface of crankshaft sleeve bore. Check external diameter (Fig. 49), also end float of cam sleeve on crankshaft sleeve. Inspect cam driving gear, ease any light scores in bore and lightly stone teeth if necessary.

Rear Cover and Auxiliary Drives
Inspection

Rear Cover. Inspect casting for cracks or flaws, especially at radii and on flanges. Check crankshaft tail shaft for fit in rear cover bush. Similarly check cross-drive shaft and gun-gear shaft bushes.

Carden Shaft Generator Drive. Inspect coupling bolts and washers and replace if unduly worn. Inspect flexible coupling discs ; if deteriorated, frayed or oil-soaked they should be replaced. Generally inspect universal coupling shaft ends, spring coupling and its drive. Examine

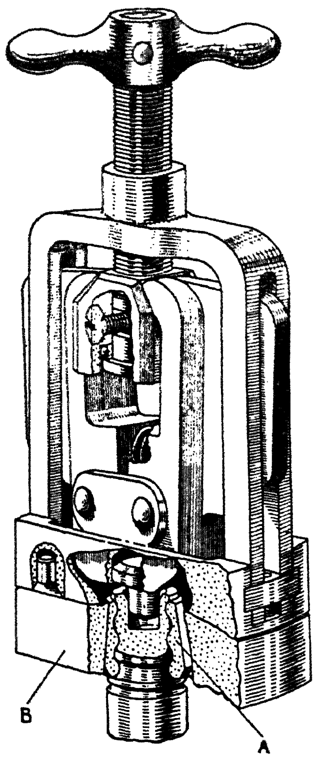


Fig. 45.—APPLICATION OF TOOL FOR EXTRACTING VALVE STEM BUTTONS.

bearings and check for fit in housings. Polish and stone gear teeth where necessary.

Flexible Shaft Generator Drive. Examine in particular the flexible shaft casing for fracture and indications of contact with casing; check security of shaft joints.

Auxiliary Drive Shaft and Gun-gear Shaft. Inspect generator driving bevel and key. Examine ball bearings for condition and fit. Check inner end of shaft for fit in bush.

Check fit of gun-gear shaft in its bushes and also check end float.

Cross-drive Shaft and Air Compressor Drive. Relieve any raised metal on oil pump driving dogs by stoning and polishing. Inspect shaft serrations and, on later engines, the six rivets securing cross-drive gear.

Examine compressor drive shaft and driving gear. Inspect fuel pump serrations or coupling (single fuel pump), also serrations at inner end of compressor drive shaft.

Magneto Drive. Examine magneto spring drive intermediate gear, driving bevel, driven bevels, also driving drums and bushes and check the various items for fit and end float.

Oil Pump. Examine oil pump casings and gears. Check diametral clearance of gears in casings. Check backlash between each pair of gears (see Fig. 50) and also end clearance, using feeler gauges. In no circumstances remove the restrictor plug.

Replacements

Cross-drive Shaft Bush. Press out old bush in rear cover and insert new bush, using fixture and drift provided. Assemble jig in position and ream bush (see Fig. 51). Finally check for finish and size.

Gun-gear Shaft Bushes. Using extractor (see Fig. 52), withdraw front bush and press in new bush using fixture. Assemble jig and ream bush bore (see Fig. 53).

Press out rear bushes and insert new ones with the combined extractor and insertor tool (Fig. 54). Ream the bush bores, using jig and reamer provided, and check for size.

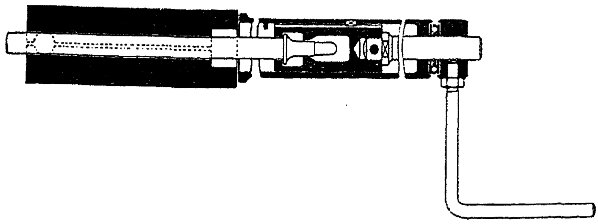


Fig. 46.—EXTRACTING PUSH ROD LOWER ENDS.

Auxiliary Drive Shaft Bush. Drill out dowel and extract bush. Drill oil hole in new bush before pressing into position, finally ensuring that the respective oil holes coincide. Ream bush bore and check for size.

Magneto Spring Drive Bushes. Press out spring drive centre bush and insert new bush. Assemble gear centre in jig, ream bush bore and check for size (see Fig. 55).

Press out bush in magneto driving bevel and similarly insert new bush. Assemble bevel in jig, ream bush bore and check for size (see Fig. 56).

UNIT ASSEMBLY AND ENGINE ERECTION

All components must be scrupulously clean and all bearing surfaces and moving parts liberally covered with clean engine oil prior to assembly.

New split pins and lock-washers should be used and the various spring retaining rings must seat correctly and be fully expanded in their grooves. Where wire locking is required, the wire must be so arranged that the slightest tendency for the parts to unscrew will be countered. Throughout the assembly procedure strict attention should be given to the assembly marks, numerals or labels on the components.

Reference should again be made to the Fits and Clearance Schedule, and the specified checks carried out at appropriate stages during assembly.

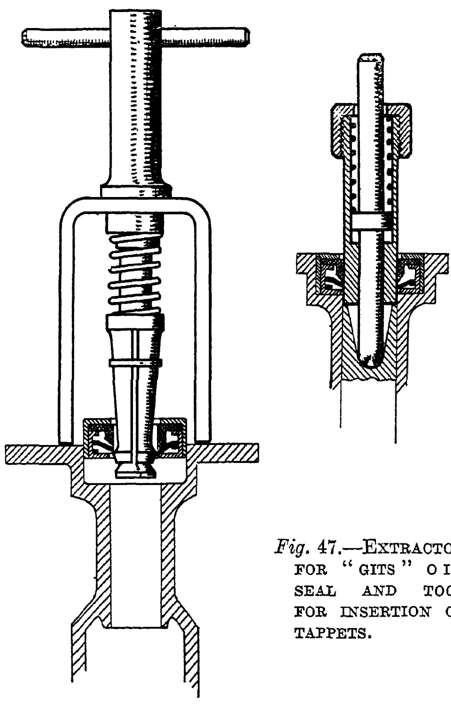


Fig. 47.—EXTRACTOR FOR "GITS" OIL SEAL AND TOOL FOR INSERTION OF TAPPETS.

Unit Assembly

Reduction Gear. The assembly sequence is identical

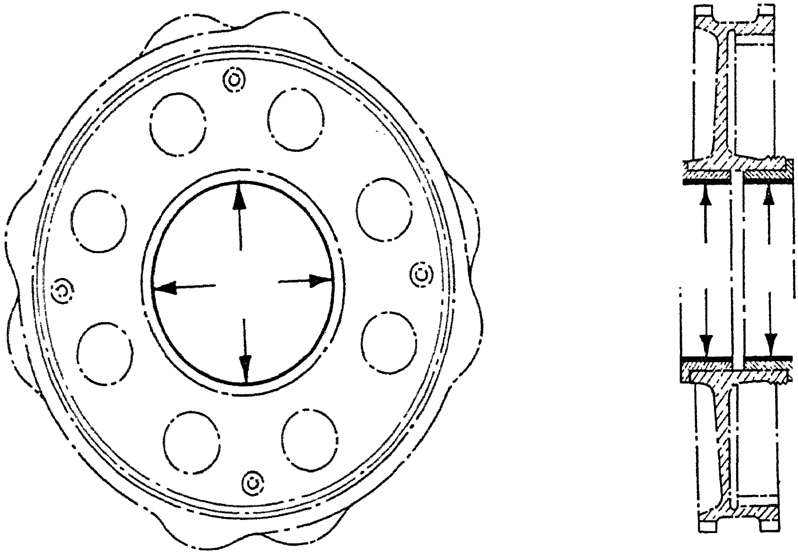


Fig. 48.—SHOWING POINTS TO CHECK BORE DIAMETER OF CAM SLEEVE BUSHES.

for the three types.

Assemble bushes to pinions and position pinions over their respective stub arms (Fig. 57). Assemble thrust bearings to stub arms with chamfered face outwards (Fig. 58), fit locking ring and nut and tighten. Position airscrew shaft in stand provided and fit the bevel gear distance washer on rear end of shaft with chamfer towards shaft radius. Assemble rear bevel gear and thrust ring. Fit thrust bearing to airscrew shaft with the marking "NO THRUST HERE" against distance washer. Assemble lock washer and tighten nut but do not lock at this stage. Tap ball bearing into front stationary gear.

Rotate rear bevel until marked teeth are aligned with oil flat on tail shaft and airscrew shaft master spline. Assemble distance washer to front end of shaft as described for rear washer. Position front bevel gear (Fig. 59) so that marked parallel teeth are aligned with those on rear bevel. Place spherical thrust ring on bevel and press ball bearing and stationary gear on to shaft, using tool provided (Fig. 60); ensure that inner race is butting firmly against distance washer and that stationary gear and bevel are correctly engaged and have not rotated relative to shaft.

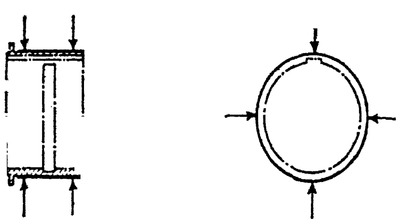


Fig. 49.—SHOWING POINTS TO CHECK OUTSIDE DIAMETER OF CRANKSHAFT SLEEVE.

Check backlash between rear

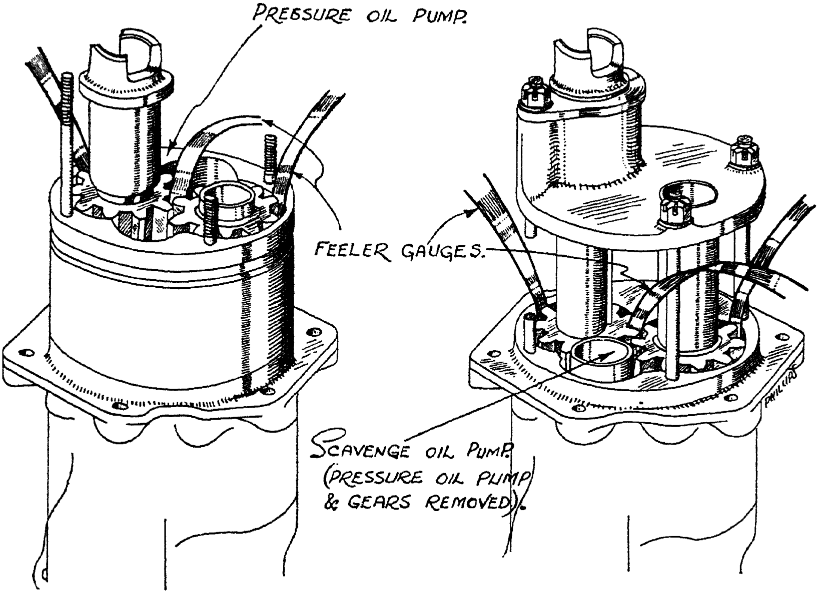


Fig. 50.—SHOWING CHECKING OF BACKLASH BETWEEN EACH PAIR OF OIL PUMP GEARS.

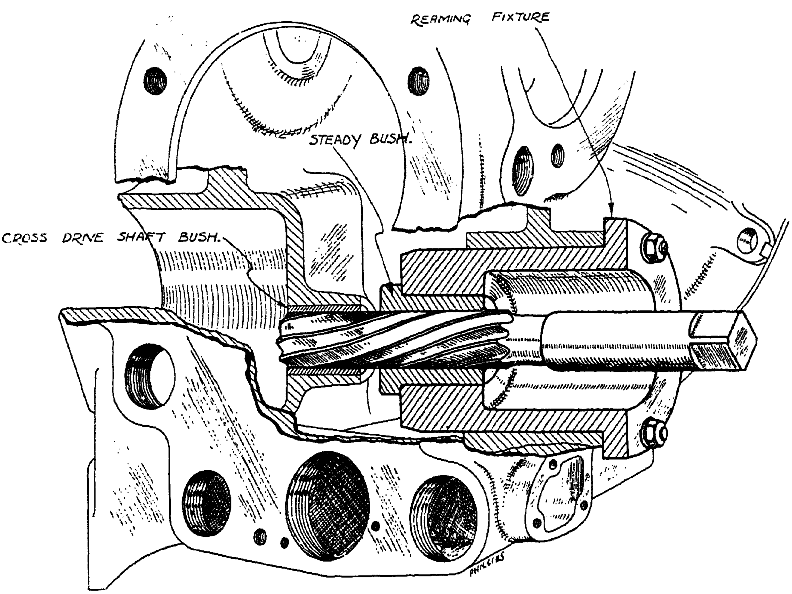
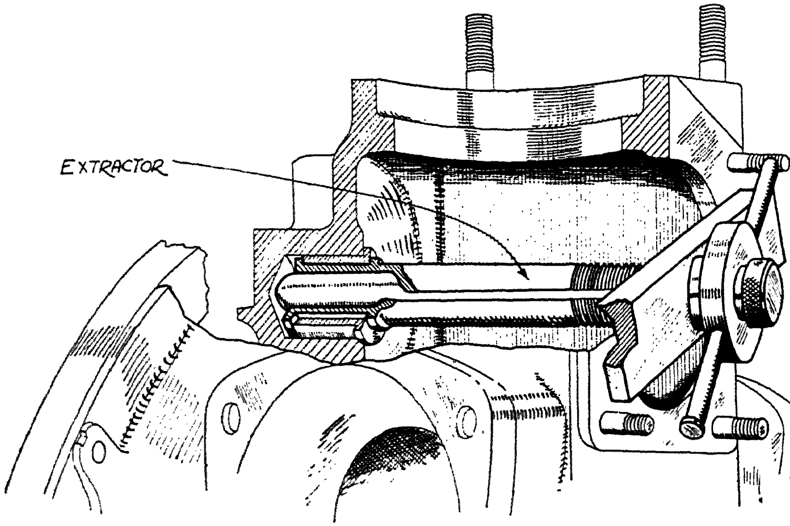
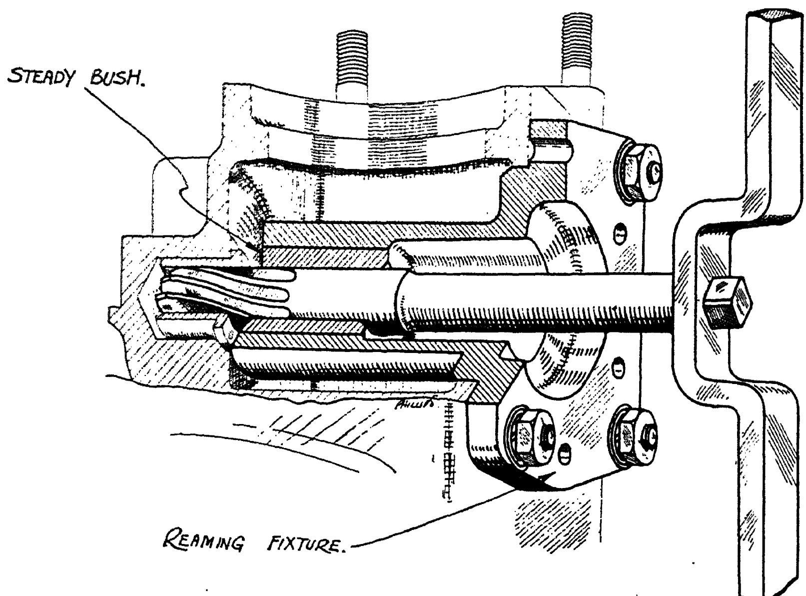


Fig. 51.—APPLICATION OF FIXTURE AND REAMING OF CROSS-DRIVE SHAFT BUSH IN REAR COVER.



52.—EXTRACTING GUN GEAR SHAFT FRONT END BUSH.



53.—REAMING GUN GEAR SHAFT FRONT END BUSH BORE.

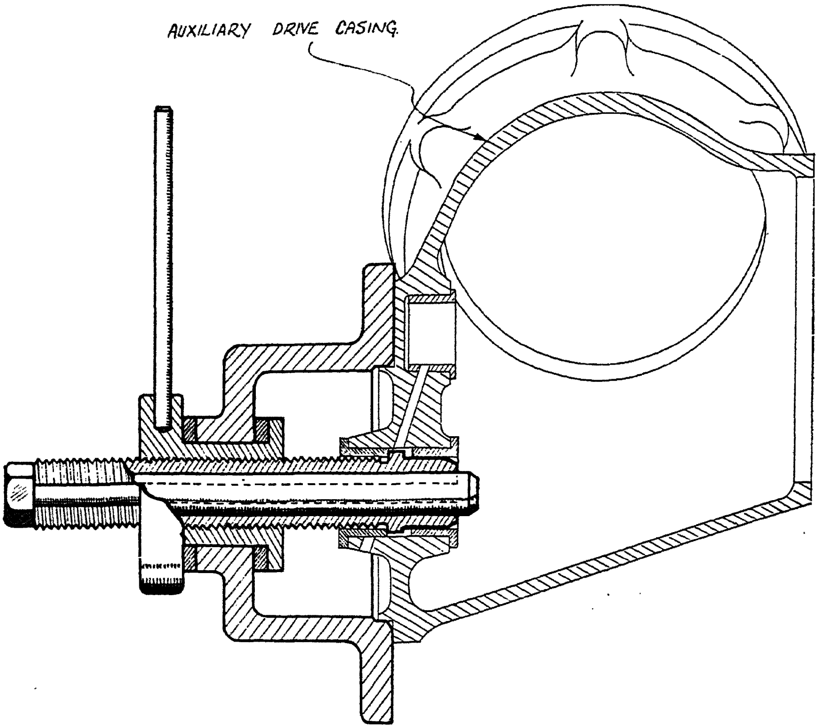


Fig. 54.—TOOL FOR INSERTING OR EXTRACTING GUN GEAR SHAFT REAR END BUSHES IN AUXILIARY DRIVE CASING.

bevel and pinions, using three sets of feeler gauges (Fig. 61). Adjustment is provided by a range of distance washers for fitment between rear bevel thrust race and its abutment.

When checking backlash between front bevel and pinions it is necessary to impose a load on the airscrew shaft to take up all end float in the thrust direction. For this purpose, assemble the unit in the fixture as shown in Fig. 62. The procedure for a 0·666 : 1 gear is as follows :—

After applying load, revolve rear bevel and pinions a few revolutions and space the centralising wedges equally around inside diameter of front bevel. Insert feeler between straight teeth of front bevel and stationary gear teeth to take up backlash. Check backlash between front bevel and pinions, employing a dial indicator as shown. Any adjustment necessary is to be effected by fitting a suitable distance washer between inner race of front ball bearing and its abutment.

With the 0·5 : 1 and 0·572 : 1 ratio gears three sets of feeler gauges may be employed in place of the dial indicator.

On satisfactory completion of backlash checks, lock rear lock nut

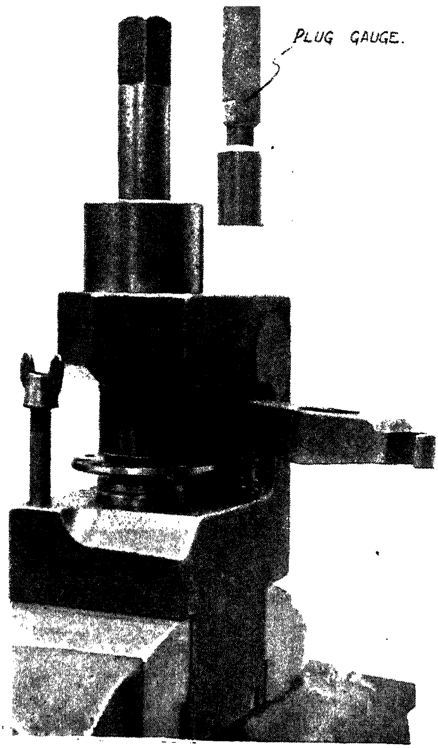


Fig. 55 (*right*).—SHOWING REAMING FIXTURE AND PLUG GAUGE FOR MAGNETO SPRING DRIVE CENTRE BUSH.

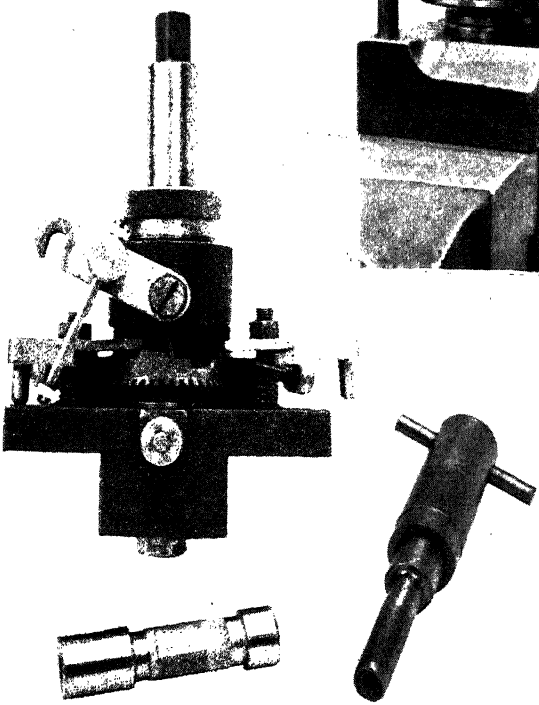


Fig. 56 (*left*).—REAMING JIG AND PLUG GAUGE FOR MAGNETO DRIVING BEVEL.

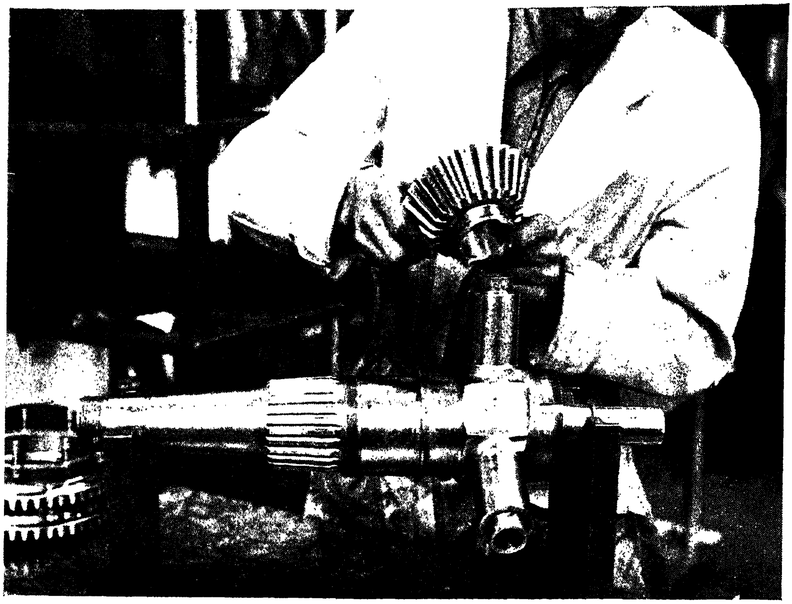


Fig. 57.—ASSEMBLING PINIONS AND BUSHES TO AIRSCREW SHAFT STUB ARMS.

and assemble gear case with the two drain holes aligned with the two holes at front of stationary gear.

Fit oil seals in housing. Compress seals and insert housing into oil transfer housing liner. Assemble rubber rings to studs and to oil transfer housing spigot. Place the two components over airscrew shaft and align transfer housing with gear case. The identification plate on gear case represents the vertical centre line through No. 1 cylinder, and the housing must be assembled so that the union will line up with V.P. airscrew oil pipe from No. 1 crankcase bolt. Press oil seal housing into position, using tool provided, taking care to keep transfer housing in the same longitudinal position relative to oil seal housing so that rear seal shall not spring out. Fit nuts and washers and securely tighten.

Assemble airscrew shaft oil thrower, tab washer and thrust nut; securely tighten latter and lock. Place felt washer in groove at forward end of thrust nut and fit new rubber ring on oil retainer cover spigot. Assemble oil retainer, positioning licence plate on top vertical centre line and secure with washers and nuts.

Supercharger

Assemble spring drive centre to gear and using pincers provided (Fig. 63) assemble spring drive pads and springs in position with outer members all facing in same direction of rotation.

Fit plates to gear, the one with tapped holes being fitted at the front.

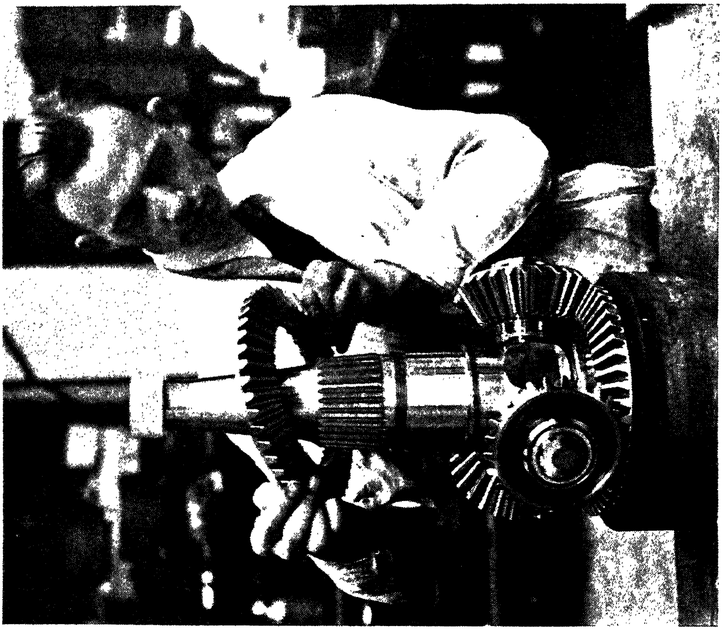


Fig. 59.—ASSEMBLING FRONT BEVEL GEAR.

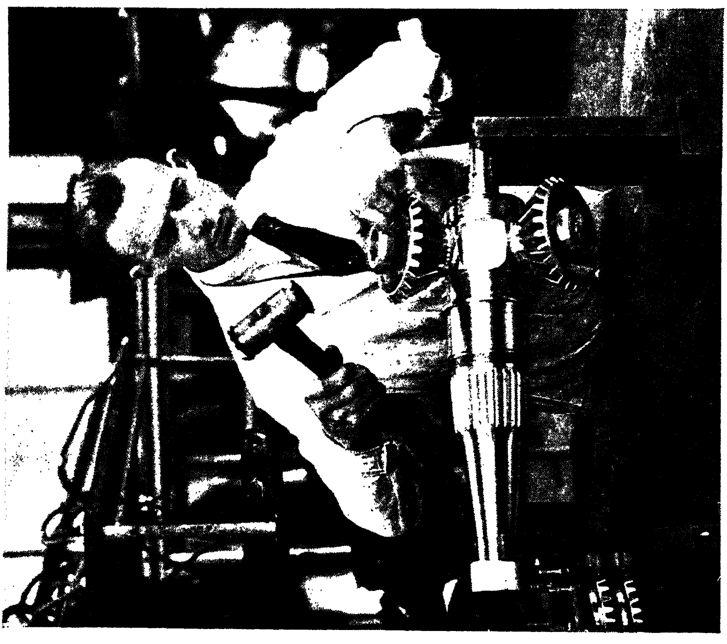


Fig. 58.—ASSEMBLING THRUST BEARINGS TO STUB ARMS WITH CHAMFERED FACE OUTWARDS.

Assemble bolts and securely tighten. After checking clearances as laid down, lock bolts by peening threaded ends.

Assemble intermediate gear side plates to gear, fit new nuts and bolts with heads toward the front and file bolts nearly flush with outer faces of nuts. Assemble balancing mandrel into bores of side plates and check for static balance on knife edges (Fig. 64). Any adjustment is to be made by filing bolt end faces. Next stamp bolt heads with numerals "1" to "16"; commence by marking the head opposite to "1" on plate and proceed in sequence until last bolt is reached, which will be marked "16" to correspond with similarly marked bolt hole. Remove bolts and nuts, taking care to segregate each nut to its respective bolt.

On early engines, press gear centre on to intermediate gear pinion, and assemble the tab washer and nut; securely tighten and lock. Assemble intermediate gear, clutch blocks and side plates (Fig. 65) to the gear centre and pinion; clutch blocks must not be mixed and must be positioned with their part number toward the front. Fit bolts and nuts in correct positions and securely tighten (Fig. 66). Lock by four punch indentations inside bolt circumference so that metal is expanded into nut. Secure spindle (Fig. 67) vertically in a vice and assemble pinion bearing inner race. Apply clean oil, preferably "Rust Veto," to tracks. Insert the eleven rollers to their specific track and lower gear unit into place. Insert the remaining rollers, followed by washer and secure with nut and collar. Using dial indicator, check alignment of assembled gear. (Malalignment should not exceed 0·005 in.) Also check end float of the gear and rollers on the centre. Repeat for the three gear assemblies.

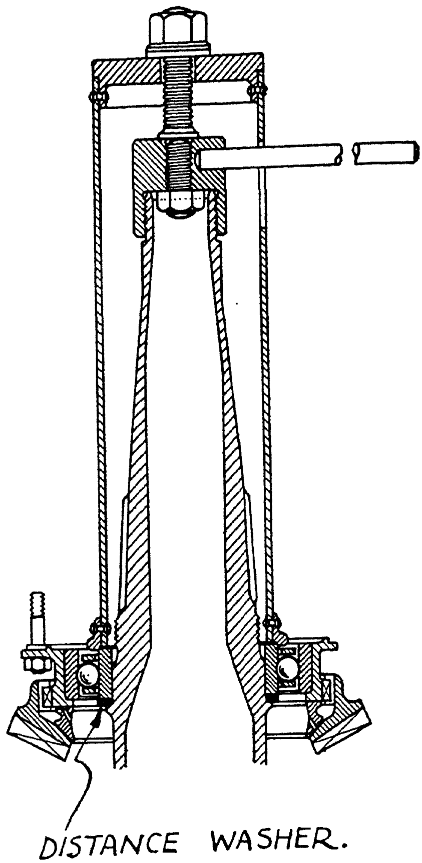


Fig. 60.—SHOWING APPLICATION OF TOOL FOR PRESSING ON FRONT BALL BEARING AND STATIONARY GEAR.

Insert front impellor gear ball bearing in its housing and fit retaining

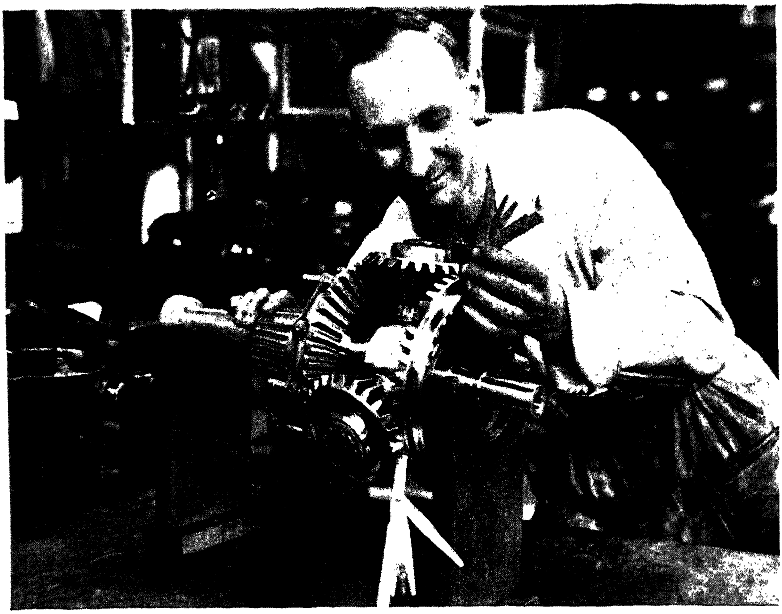


Fig. 61.—CHECKING BACKLASH OF REAR BEVEL GEAR AND PINIONS.

ring. Place front oil thrower in position with narrow shoulder against inner race. Assemble intermediate gears to their respective support bolts and fit the washers. Press on bearing support ring and assemble nuts and tab washers ; securely tighten and lock (Fig. 68).

With blower casing supported on the special sleeve, assemble impellor gear into bore of oil thrower and front bearing, using drift provided. Invert casing, mount on stand and fit front oil seal retainer and seal. Apply " Lanoline " to impellor splines and assemble, using appropriate hollow drift provided. Ensure that master splines are aligned before tapping home. Screw on support sleeve and tighten (Fig. 69).

Checking Impellor Clearances.—First, gauge maximum clearance between impellor and blower casing. Take up end float in bearing and end clearance of outer race in its housing by tapping impellor gear rearwards, meanwhile supporting assembly on stand. Insert two sets of feeler gauges diametrally opposite to one another between face of blower casing and front end faces of impellor vanes. Next check minimum clearance between impellor and volute casing and clearance between guide vanes and volute casing employing beam gauges " A " and " B " (Figs. 70, 71 and 72).

Secure feet of gauge " A " on annular joint face of blower casing as shown and adjust centre blade to impellor vanes, using a 0·0015-in. feeler as " GO " and a 0·003-in. feeler as " NOT GO " gauge ; check with different

impellor positions. Similarly adjust the other blade to the guide vane faces.

Carefully transfer setting of gauge "A" to gauge "B" (Fig. 71), using 0·0015-in. and 0·003-in. feelers as before. Place gauge "B" on annular joint face of the volute casing and check clearance between blades and faces of volute casing (Fig. 72).

Next measure minimum clearance between impellor and blower casing and maximum clearance between impellor and volute casing, employing the same methods as already described. The blower casing should be removed from stand and supported on two wood blocks. Tap impellor gear in a forward direction until bearing outer race is butting against its retaining ring and take up bearing end float by placing suitable weight on support sleeve.

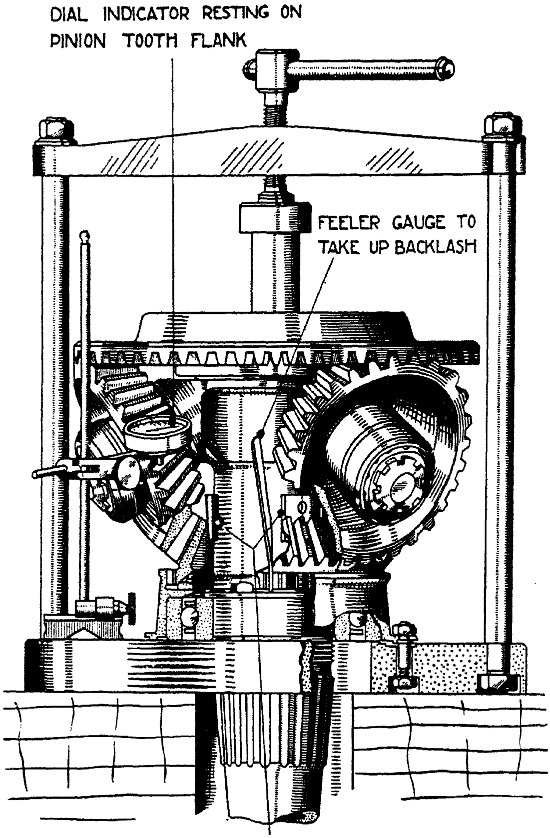


Fig. 62.—FIXTURE FOR CHECKING BACKLASH OF FRONT BEVEL GEAR.

Apply approved jointing compound to joint faces of blower and volute casing and assemble in position (Fig. 73); fit nuts and washers and securely tighten. Assemble the two oil seals, with gaps diametrally opposite, to the rear retainer and assemble retainer to impellor gear, *with flanged end toward the impellor*. Insert the three springs and pads in front face of the bearing housing bore. Tap rear bearing into position, using drift provided, with the unengraved faces of races toward pads. Ensure that outer race can be rotated in its housing. Assemble oil thrower with the narrow shoulder against inner race, followed by lock ring and shaft nut; securely tighten and lock. Fit oil trough and lock the three screws with wire.

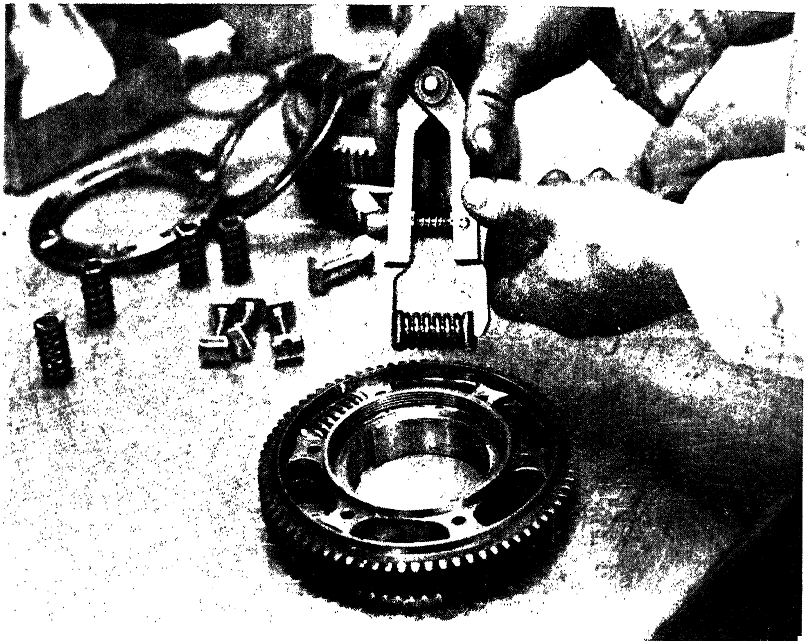


Fig. 63.—SHOWING COMPRESSING TOOL FOR ASSEMBLING SPRING DRIVE PADS AND SPRINGS TO SPRING DRIVE GEAR.

Finally apply jointing compound to induction elbow and assemble to volute casing.

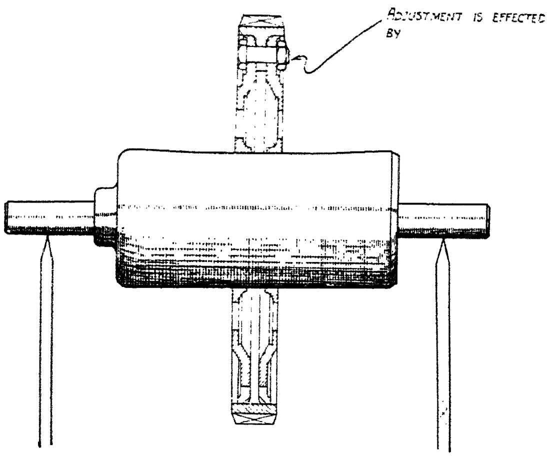
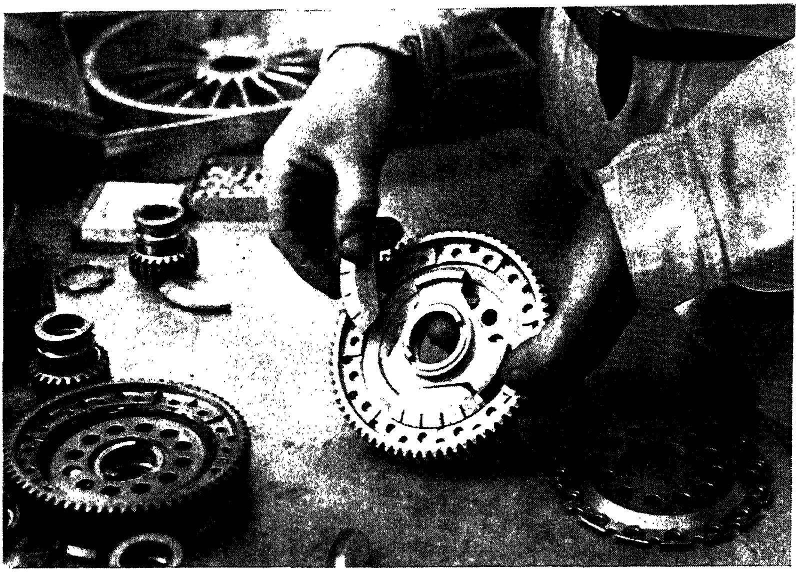


Fig. 64.—SHOWING MANDREL AND KNIFE EDGES FOR CHECKING STATIC BALANCE OF INTERMEDIATE GEAR.

Crankshaft and Connecting Rod Assembly

Crankshaft.—If oil sleeve has been removed, reassemble, using tool provided; fit circlip, using the special pliers. Replace front and rear crankpin oil caps and tab washers, first smearing threads and under faces of both caps with "Lanoline."

Assemble tail shaft with small oil holes positioned on



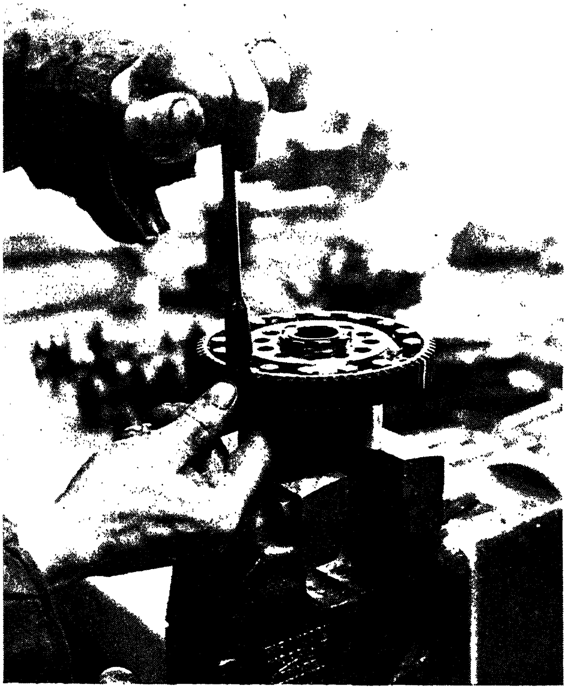


Fig. 65 (*above*).—ASSEMBLING CLUTCH BLOCKS, INTERMEDIATE GEAR CENTRE AND SIDE PLATES.

Fig. 66 (*right*).—TIGHTENING INTERMEDIATE GEAR BOLTS AND NUTS.

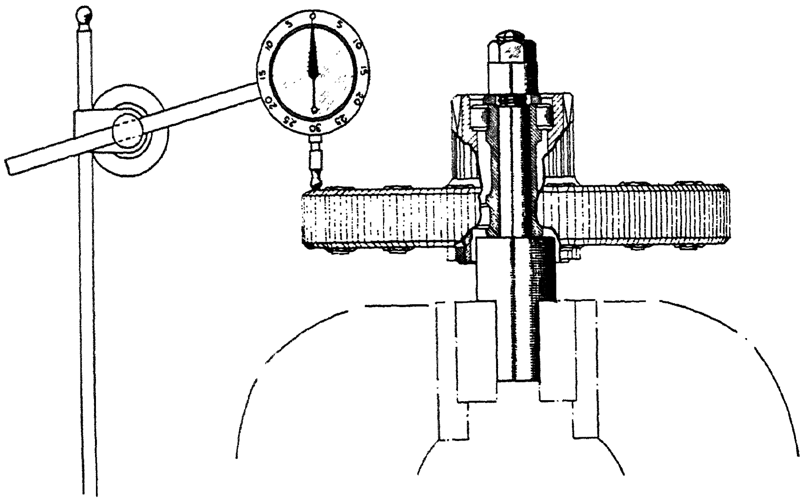


Fig. 67.—CHECKING ALIGNMENT OF INTERMEDIATE GEAR AND PINION UNIT.

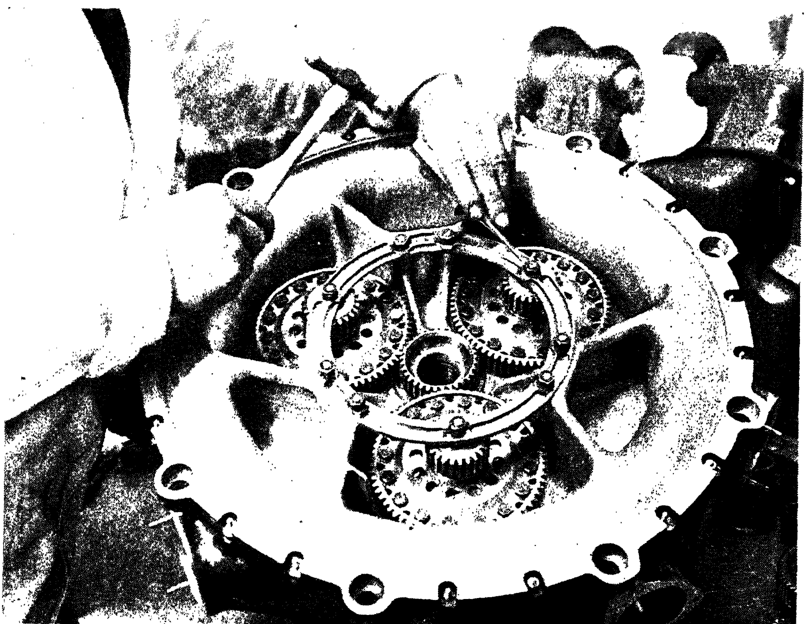


Fig. 68.—BENDING UP TAB WASHERS TO LOCK INTERMEDIATE GEAR SUPPORT BOLT NUTS.

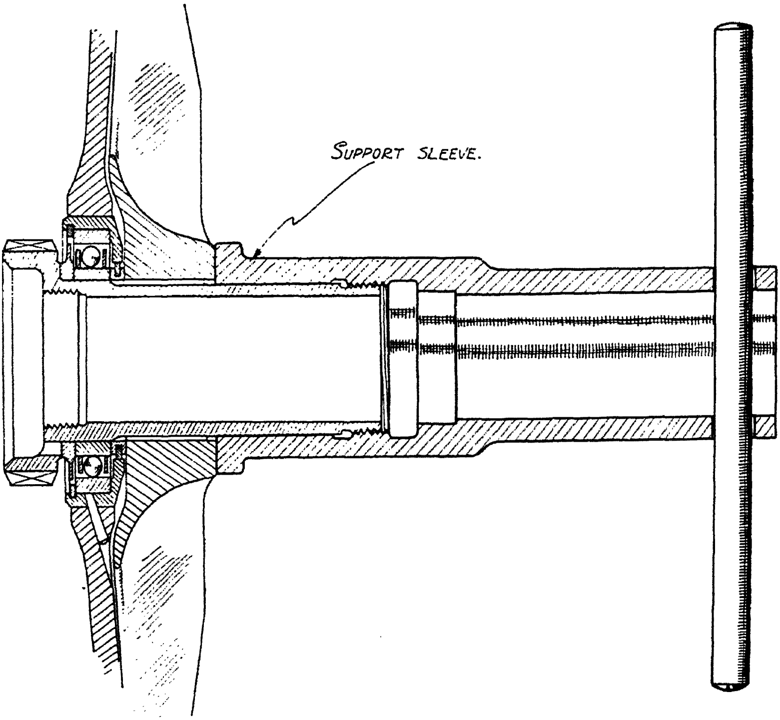


Fig. 69.—SHOWING APPLICATION OF SUPPORT SLEEVE FOR CHECKING IMPELLOR CLEARANCES.

vertical centre line. Fit distance piece and retaining ring. Assemble felt ring and packing sleeve to front end of the tail shaft, followed by spring. Smear threads and taper face of rear crankshaft plug with "Lanoline" and assemble to shaft, ensuring that spring spigots over plug flange. Tighten and lock with tab washer and set screw. Similarly assemble plug to front half crankshaft.

Connecting Rod Assembly.—Check end float of floating bush. Temporarily assemble front and rear oil retainers (without springs) to master rod and lay components front face downwards on surface plate. Place floating bush in position, radiused end downward. With dial indicator check oil retainer face and end face of bush.

Remove components and retain master rod firmly in vice, using hard wood blocks as when dismantling. The following points should be observed when assembling the articulated rods and wrist pins :—

(*a*) Both rods and pins are to be assembled in their correctly numbered positions, the rods with their part number and position numeral towards front of engine.

(*b*) Wrist pins must be assembled with line engraved on front (taper) end face aligned with line on front face of master rod flange.

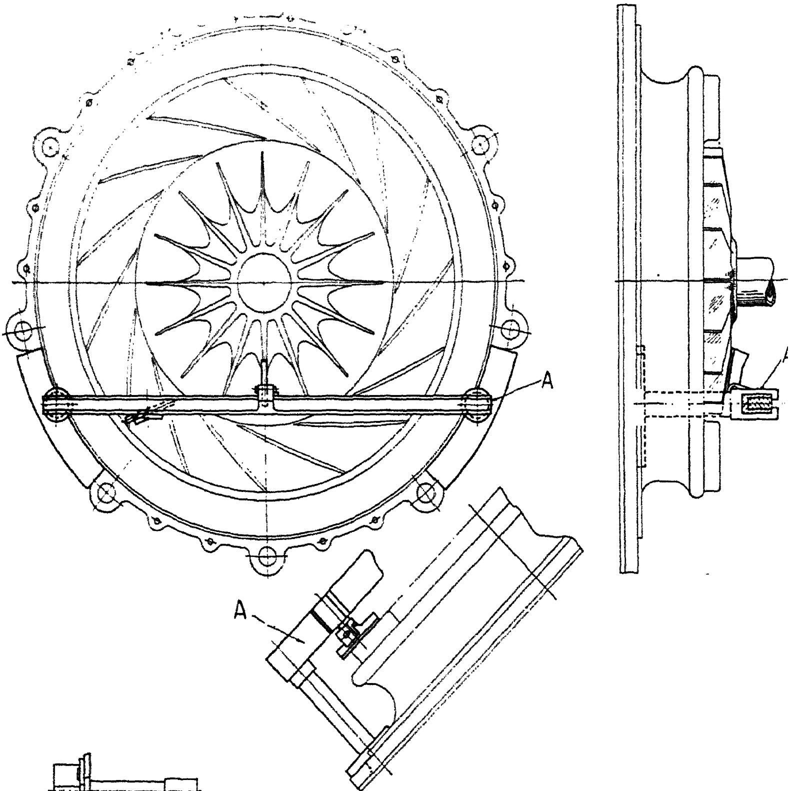


Fig. 70.—SETTING OF BEAM GAUGE FOR CHECKING IMPELLOR AND GUIDE VANE CLEARANCES.

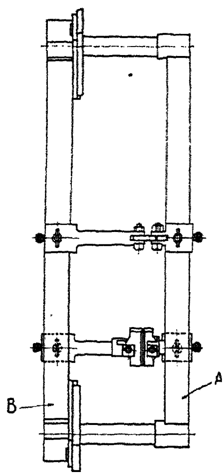


Fig. 71.—SHOWING TRANSFERENCE OF GAUGE SETTING.

Apply engine oil to bushes and "Lanoline" to parallel ends of pins (Fig. 74). Assemble articulated rods to master rod and fit pins, using the drift. Assemble front oil retainer and wrist pin bolts and nuts, noting that the retainer locating bush is positioned in No. 4 wrist pin bore. Securely tighten nuts, using the two spanners provided; avoid over-stressing threads. Lock nuts with split pins.

Secure front half crankshaft in a vice, using vice clamp. Oil floating bush and assemble it to crankpin, radiused end to the front. Assemble connecting rod unit on crankpin (Fig. 75). Fit the three springs and plungers into Nos. 1, 4 and 7 wrist-pin bores,

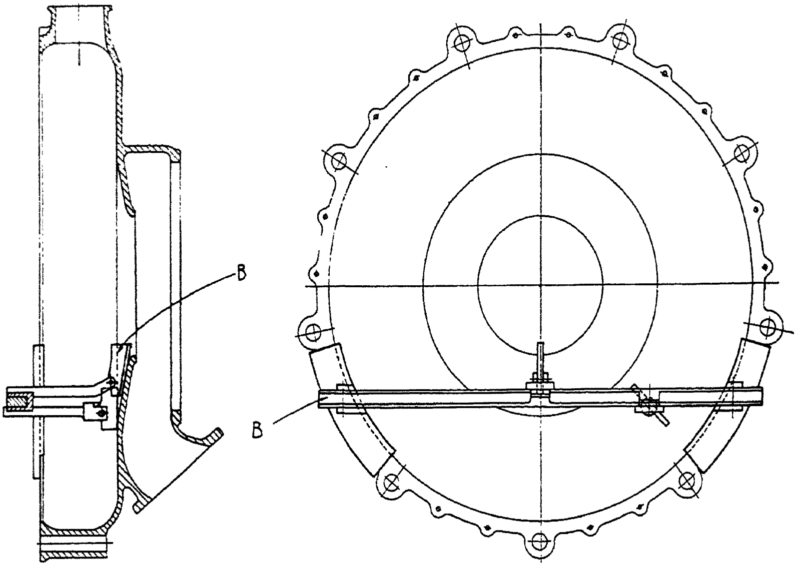


Fig. 72.—CHECKING CLEARANCES BETWEEN GAUGE BLADES AND VOLUTE CASING.

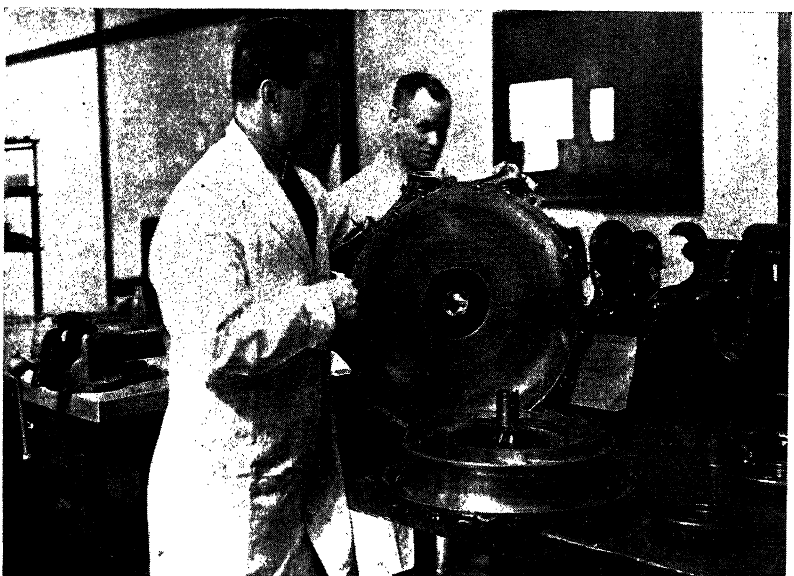


Fig. 73.—SHOWING VOLUTE CASING READY FOR ASSEMBLY TO BLOWER CASING.

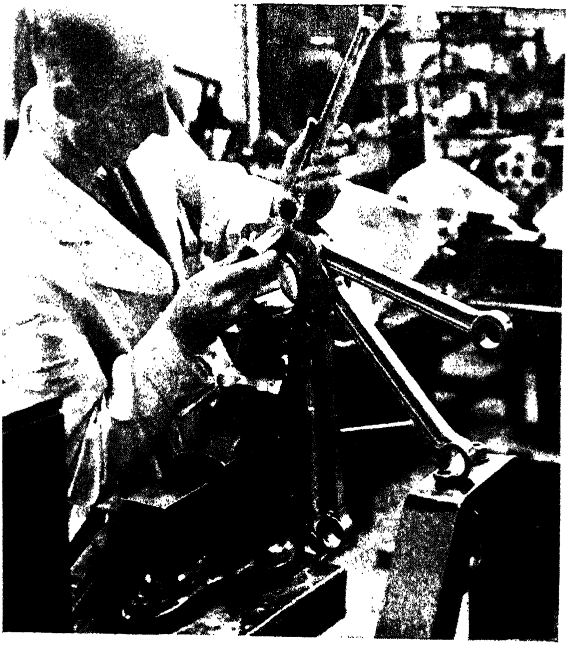


Fig. 74 (*left*).—ASSEMBLING ARTICULATED RODS AND WRIST PINS TO MASTER ROD.

Fig. 75 (*below*).—ASSEMBLING CONNECTING ROD UNIT OVER CRANKPIN.

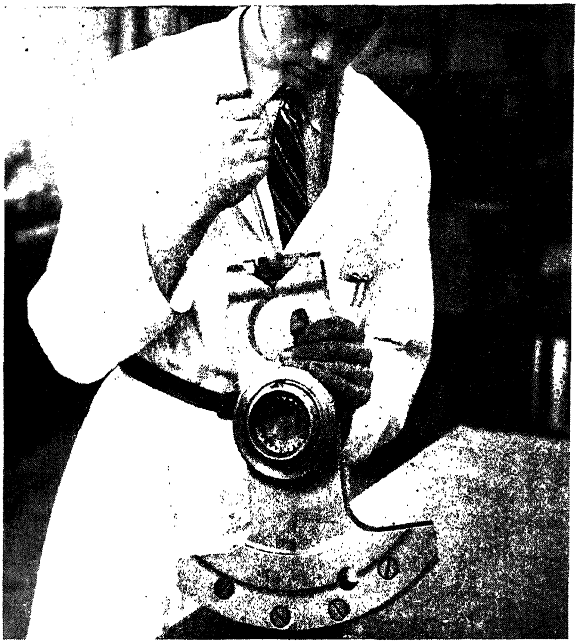
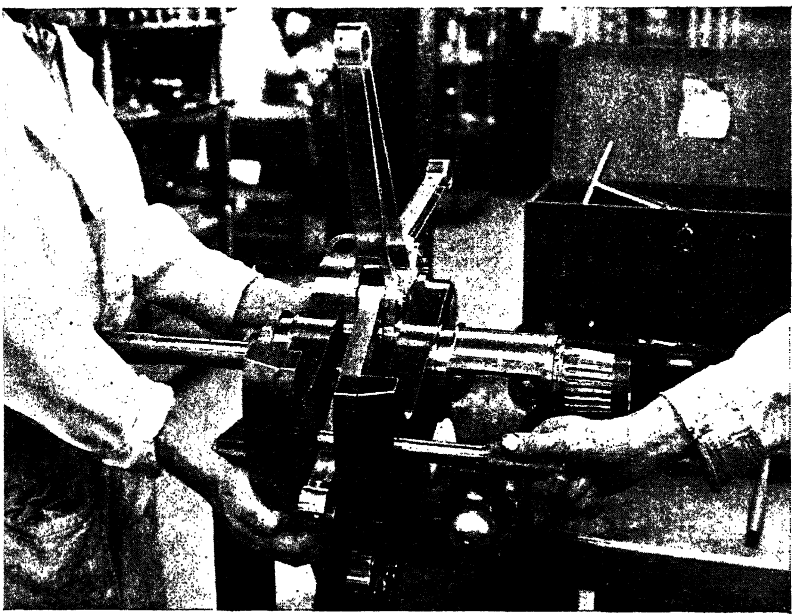


Fig. 76 (*right*).—SHOWING APPLICATION OF EXPANDING TOOL IN THE "VEE" REAR HALF CRANKSHAFT.

Fig. 77 (*below*). — SHOWING INSERTION OF ALIGNMENT PLUG TO LINE UP FRONT AND REAR HALVES OF CRANKSHAFT.



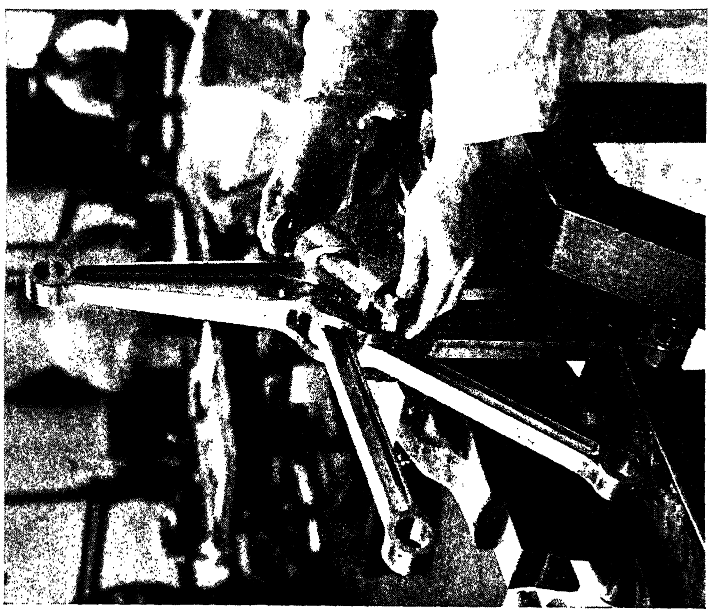


Fig. 78.—ASSEMBLY OF MANETON BOLT AND NUT.

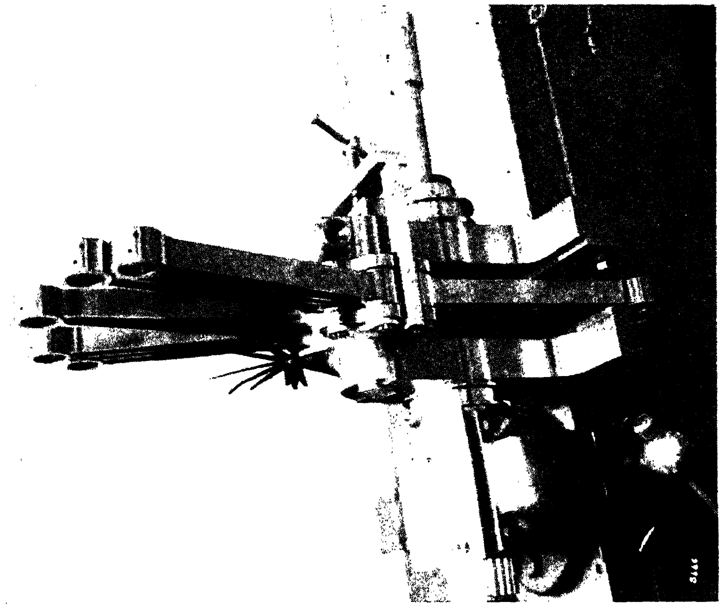


Fig. 79.—CHECKING CLEARANCE BETWEEN OIL RETAINER AND FRONT HALF CRANKSHAFT.

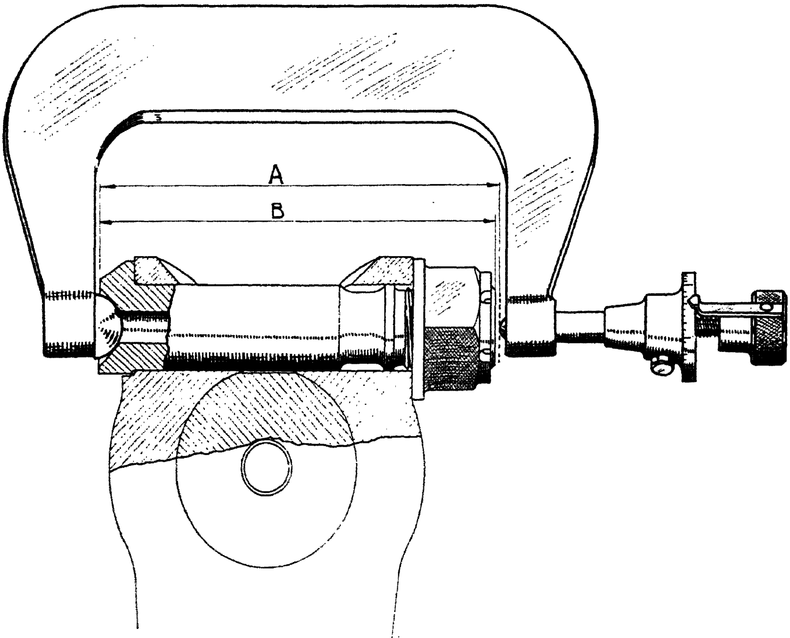


Fig. 80.—DIAGRAM SHOWING DIMENSIONS BEFORE AND AFTER TIGHTENING MANETON BOLT NUT.

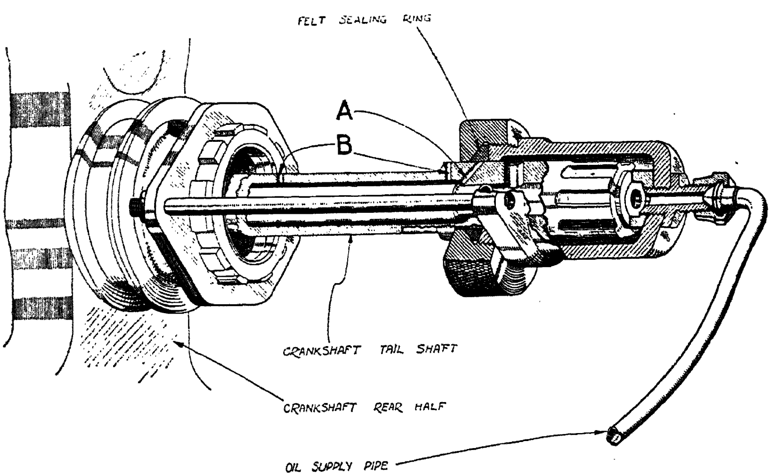


Fig. 81.—SHOWING FEED ATTACHMENT FOR CRANKSHAFT OIL PRESSURE TEST.

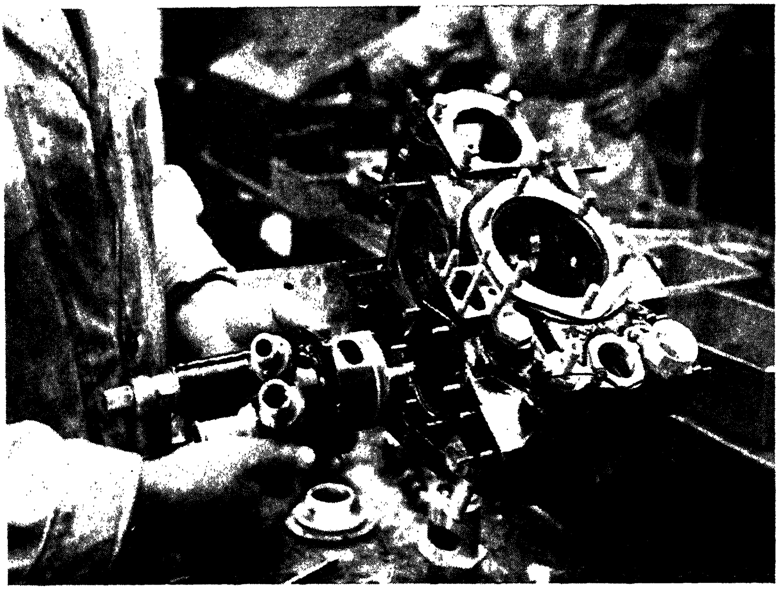


Fig. 82.—ASSEMBLY OF OIL PUMP TO REAR COVER.

followed by rear oil retainer with its tongue locating in master rod channel.

Ensure that crankpin and maneton bore are scrupulously clean and *free from oil or grease of any kind.* Expand maneton bore, using expander (Fig. 76) and fit rear half crankshaft on to crankpin. Align the two halves by sliding the alignment plug through the holes in both balance weights (Fig. 77). Remove expander and assemble maneton bolt and nut finger tight (Fig. 78). Compress rear retainer springs, using tool, and with feeler gauges check end clearance between oil retainer front face and crankshaft face (Fig. 79). Should adjustment be required, withdraw maneton bolt and ease grip of maneton bore with expander before tapping rear half crankshaft in the desired direction. Refit maneton bolt and nut and check alignment of the two halves.

Mount crankshaft assembly in the appropriate fixture and obtain requisite tightness of maneton bolt and nut as follows : with maneton nut assembled finger tight, measure length of bolt by means of micrometer and obtain dimension " A " (Fig. 80). Tighten nut until the bolt elongation, *i.e.*, dimension " B " minus dimension " A," is between 0·009 in. and 0·010 in. When split pin hole and nut slot are not aligned, slack back nut and retighten until they are in alignment. Recheck bolt elongation ; this should not be greater than 0·010 in.

A final check of connecting rod assembly end float and of alignment of front and rear half crankshaft should be made. Prior to removing

assembly from fixture, fit the split pin, bending one leg over end face of bolt and the other against face of nut.

Oil Pressure Test (Fig. 81).—Blank off front end of shaft, using threaded plug. Feed oil into crankshaft, using the attachment on the tail shaft; maintain a pressure of 80 lbs. per square inch throughout test. Observe that :—

(*a*) There is a free flow of oil from behind intermediate inner race.

(*b*) Oil is exuding freely from around pin ends of articulated rods.

(*c*) Oil is exuding from the two small holes in crankshaft tail shaft (see following paragraph).

(*d*) Oil is exuding *viâ* bore of front half crankshaft.

(*e*) All plugs are oil tight. A slight leak *viâ* tail shaft packing ring and around front oil retainer adjacent to master rod channel is permissible.

With oil hole " A " blanked off by the felt ring in the feed attachment, no oil should exude from the two holes " B " in the tail shaft. If oil does exude under these conditions it is evident that it is leaking past the oil sleeve joint, which should be pressure tight. Make a separate check to ensure that oil holes " A " and " B " are clean.

Front Cover

Assemble rear roller bearing inner race to layshaft, followed by layshaft gear with markings aligned. Fit washer and rear portion of front inner race. Finally assemble rear roller bearing race complete with housing to inner race and assemble unit to front cover. Fit front portion of front inner race, followed by tab washer and nut. Assemble tab washers and nuts to rear bearing housing studs. Lock nuts after checking end float of layshaft assembly.

Rocker, Cylinder and Valve Assemblies

Rocker Unit.—Assemble the ball bearings in front and rear ends of rocker bracket. Fit front ball bearing in front end of exhaust rocker, followed by the long-distance piece and rear ball bearing. Fit cork retainer to each exhaust rocker, followed by the distance pieces with plain sides outermost. Fit retainers and end flange to ball bearing at front end of rocker bracket.

Assemble exhaust rocker unit to bracket and press inlet shaft into position, using tool provided. Assemble retainer washer, spring and grease retainer shoulder outward and fit retainer cap. Tighten the two screws and lock by peening. Assemble inlet rocker arms, fit the plain washer and nut and securely tighten. Screw plug into bore of inlet shaft and split pin the nut.

Assemble cylinder lugs to trunnion arms, using tool provided. Fit washers and nuts and after tightening check clearance between face of washer and end face of lug. Lock nuts with split pins. Assemble

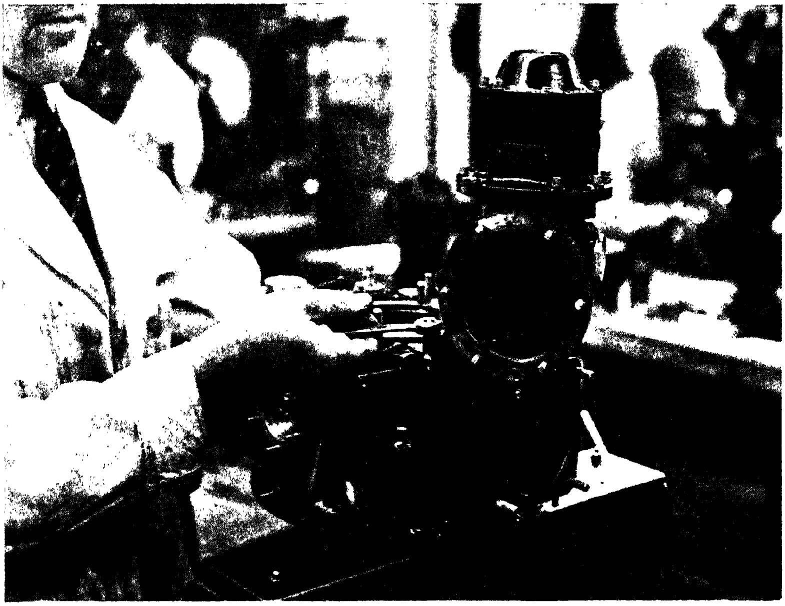


Fig. 83.—TIGHTENING AUXILIARY DRIVE CASING IN POSITION ON REAR COVER.

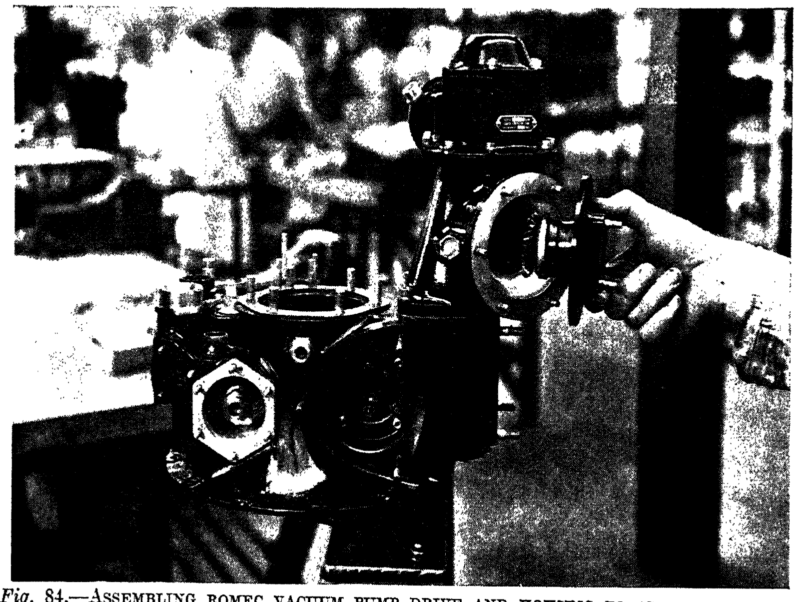


Fig. 84.—ASSEMBLING ROMEC VACUUM PUMP DRIVE AND HOUSING TO AUXILIARY DRIVE CASING.

rocker unit to the cylinder and check that lug base is bedding on head.

Cylinders and Valves.—Smear valve stems with approved grease and assemble each to its respective guide. Place cylinder on wooden dolly and assemble the lower valve spring washers after smearing with grease. Fit new rubber ring to each inlet valve guide and assemble valve seal spring, followed by valve seal. Finally position retainer to seat on lower washer. Assemble valve springs and ensure that coils locate over washer spigot. Assemble upper washers, compress springs and fit split cotters.

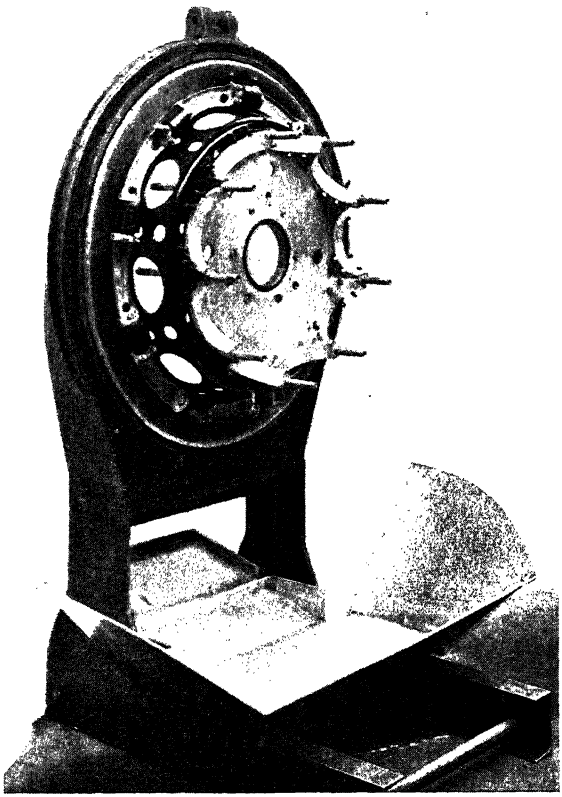


Fig. 85.—SHOWING REAR HALF CRANKCASE ASSEMBLED TO CONE MOUNTING WITH FLEXIBLE RUBBER MOUNTING UNITS IN POSITION.

Rear Cover and Auxiliaries

Oil Pump.—Insert driving spindle into pump cover and fit pressure-pump driving wheel and bearing collar. Place driven wheel in pressure pump casing. Ensure that the figures " X " engraved on the end face of both driving and driven wheels face one another. Assemble pump cover to pressure casing and fit scavenge pump driving wheel. Fit driven wheel on driven wheel spindle. Assemble pressure pump casing, with components, to scavenge pump casing. Fit check valve, spring and bridge piece; assemble retaining plate over driving spindle and two long studs and loosely secure with nuts. Insert whole assembly in the alignment jig and securely tighten nuts. Check freedom of driving spindle before locking nuts.

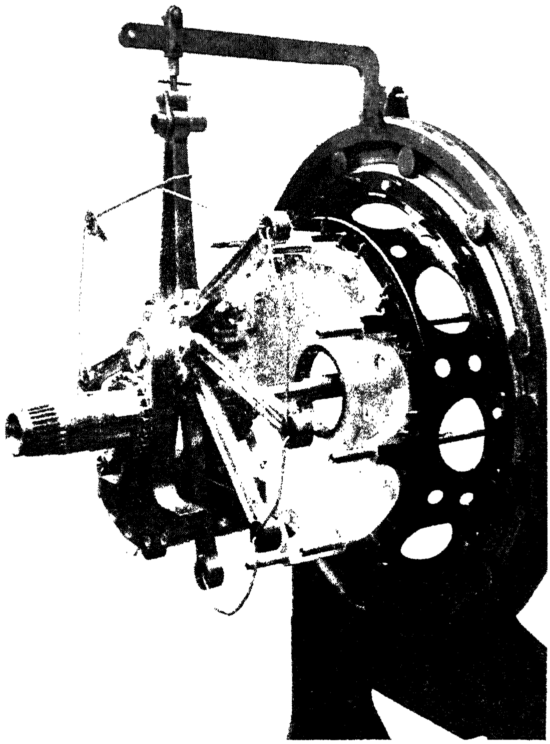


Fig. 86.—CONNECTING ROD ASSEMBLY SUSPENDED ON JIB FOR ASSEMBLY TO CRANKCASE.

Assemble relief valve, spring and cage and screw valve cap complete into position. Replace high initial oil pressure valve, spring, bridge and cap.

Assembly of Oil Pump to Rear Cover.—Fit new rubber ring on scavenge casing locating flange, and in pressure pump casing groove. Assemble pump to cover, ensuring that dowel and hole are aligned (Fig. 82).

Magneto Spring Drive. — Assemble driving bevel to intermediate gear and insert springs, employing fixture provided. Assemble spring drive centre and driving bevel bush; temporarily fit bolts. Check end float of both spring drive unit and bevel gear. Fit spindle and shim to rear cover and assemble centre bush and spring drive unit.

Magneto Drive Coupling.—Assemble bevel and driving drum in bevel housing and fit the components complete to rear cover with shims interposed; ensure oil holes are aligned. Check alignment and backlash, and if satisfactory tighten the various nuts.

Cross Drive Shaft Assembly.—Assemble ball bearing to drive housing and fit retaining ring. Tap cross drive shaft into position and assemble tachometer driving gear; fit nut and lock. If drive is to be blanked off, assemble the oil thrower.

The cross drive shaft assembly is finally fitted to the rear cover *after* the cover has been fitted to the engine.

Air Compressor and Fuel Pump Drive.—Press ball bearing into the housing and insert driven bevel; fit nut and lock. Place shim on compressor drive casing and fit housing complete, followed by retainer.

Secure with nuts but do not lock. Fit shim on driving shaft followed by ball bearing, washer and retaining nut; tighten but do not lock. Insert assembly into drive casing and fit bearing retaining ring; fit outer ball bearing and circlip. Check alignment and backlash, and if satisfactory, lock all nuts. If single-type fuel pump is fitted, or drive is to be blanked off, the oil thrower, flange and coupling must be assembled.

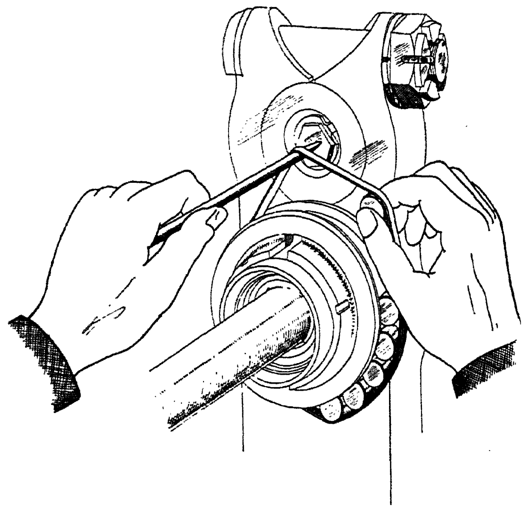


Fig. 87.—SHOWING METHOD OF ASSEMBLING BEARING ROLLERS AND RETAINING IN POSITION WITH RUBBER BAND.

Fitting Compressor Drive to Rear Cover.—Fit oil connection in bore of drive coupling before inserting into position. Assemble drive casing to rear cover (the stud situated inside the casing must be fitted with a tab washer). If compressor is not required, fit the ball bearing to casing cover, secure with retaining ring and assemble cover into position. Finally fit fuel pump.

Auxiliary Drives

Apply approved jointing compound to joint faces except where otherwise stated.

Gun Gear Shaft and Auxiliary Drive Casing.—Fit and bed the gun gear shaft key and insert shaft into bush in auxiliary drive casing. Assemble bevel gear and secure with locknut; check end float before locking. Fit the shim and assemble auxiliary drive casing to rear cover (Fig. 83). (On later engines, the fourth stud situated inside the casing is to be fitted with a tab washer.)

Rotoplunge Pump Drive.—Assemble the ball bearing into its housing and fit retaining ring. Insert drive shaft and fit distance piece, ball bearing, oil retainer, distance piece, tab washer and locknut; tighten nut and lock. Fit driving spindle and check alignment and backlash of bevel gears. On completion, finally assemble housing in position, followed by adapter and Rotoplunge pump.

Auxiliary Drive Shaft.—Assemble the ball bearing in generator drive casing and fit retaining ring. Insert auxiliary drive shaft and assemble

Fig. 88.—AFTER FITTING EACH PISTON CHECK GUDGEON PIN CIRCLIPS FOR SECURITY AND THAT PIN IS FREE TO ROTATE.

shim and distance piece to shaft. Fit the key, generator driving bevel, ball bearing, distance piece, tab washer and nut.

If Romec vacuum pump or R.A.E. air compressor is to be fitted, temporarily assemble bearing housing to auxiliary drive casing and temporarily fit shim and adapter to rear joint face of casing; fit nuts and tab washers but do not lock. Temporarily fit generator drive casing, complete with shaft, to adapter. If neither pump nor compressor drive is to be fitted, the adapter and casing may be fitted permanently.

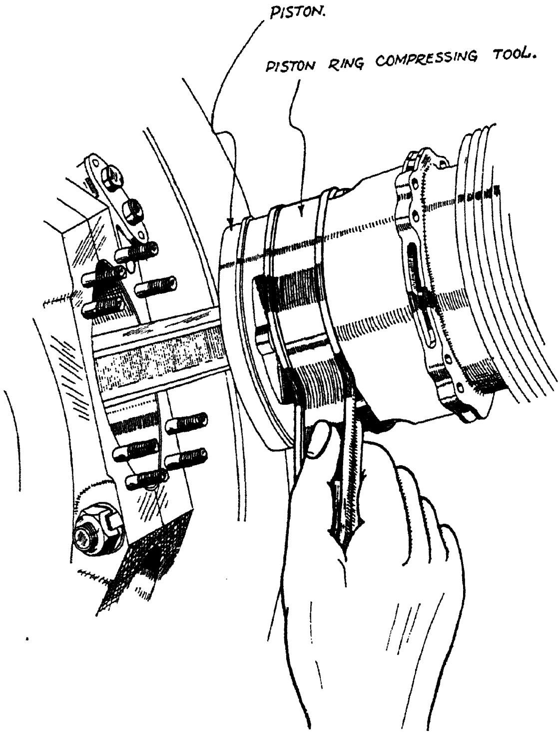
R.A.E. Air Compressor and Drive.—Assemble the ball bearing in its housing and insert the bevel gear and tab washer; fit nut and lock. Assemble the shim, housing and bearing retainer, and after checking alignment and backlash, finally assemble drive and fit compressor or blanking plate.

Romec Vacuum Pump and Drive.—Assemble the ball bearing in the drive housing and fit the retaining ring. Insert driven shaft and fit distance piece, ball bearing and tab washer; screw on nut but do not lock at this stage. Check alignment and backlash of gears before finally assembling shim and drive housing to auxiliary drive casing (Fig. 84). On completion of checks, lock shaft nut and finally assemble drive housing, after which fit pump or blanking plate.

ENGINE ERECTION

1. Assemble cone mounting to erection stand. When flexible rubber mounting is used and the special stand is available, assemble the flexible mounting to the cone mounting as follows :—

Assemble each flexible mounting block and support bracket around the cone. Ensure that the two brackets, forming the anchorage for the lifting link, are positioned on either side of the vertical centre line of No. 1 cylinder. The solid end of rubber mounting inner sleeve should



89.—SHOWING USE OF PISTON RING COMPRESSING TOOL WHEN ASSEMBLING CYLINDER OVER PISTON.

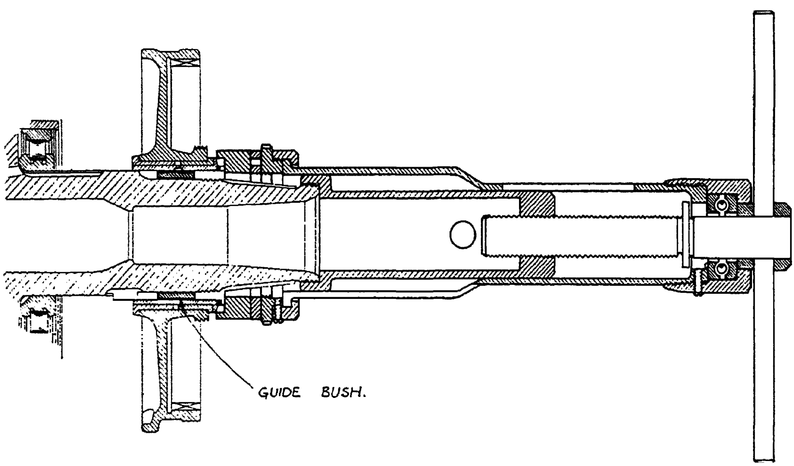


Fig. 90.—SIMULTANEOUS ASSEMBLY OF CRANKSHAFT SLEEVE AND CAM SLEEVE.

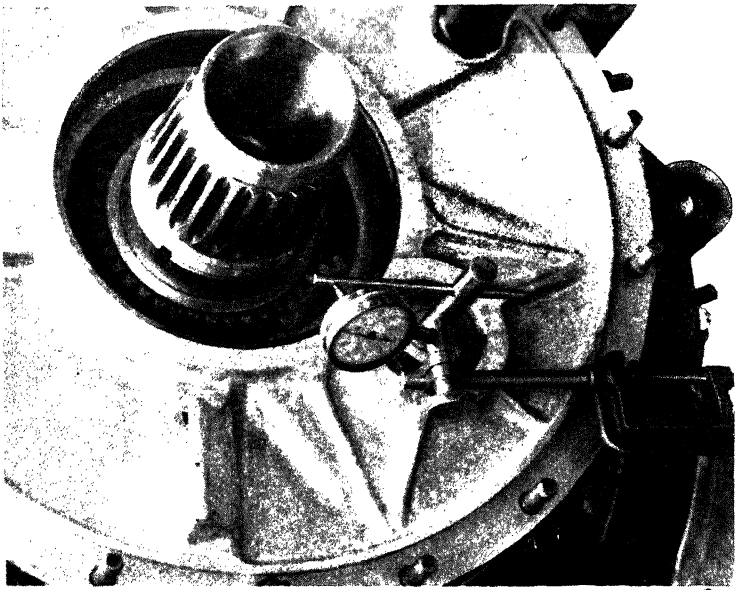


Fig. 92.—CHECKING BACKLASH OF LAYSHAFT GEAR AND CAM

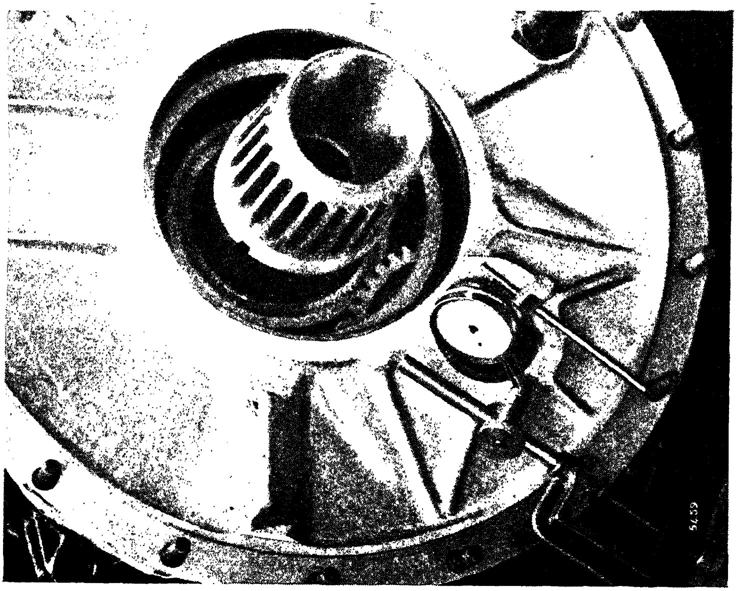


Fig. 91.—CHECKING BACKLASH OF LAYSHAFT PINION AND CAM GEAR

be fitted toward the cap support bracket. Loosely assemble the eighteen bolts and nuts and secure support brackets to cone mounting. Tighten and split pin the trunnion bolts. Equally space support brackets and tighten and lock nuts securing cap support brackets. Next tighten and lock the eighteen bolts and nuts securing support brackets to cone mounting; fit lifting link.

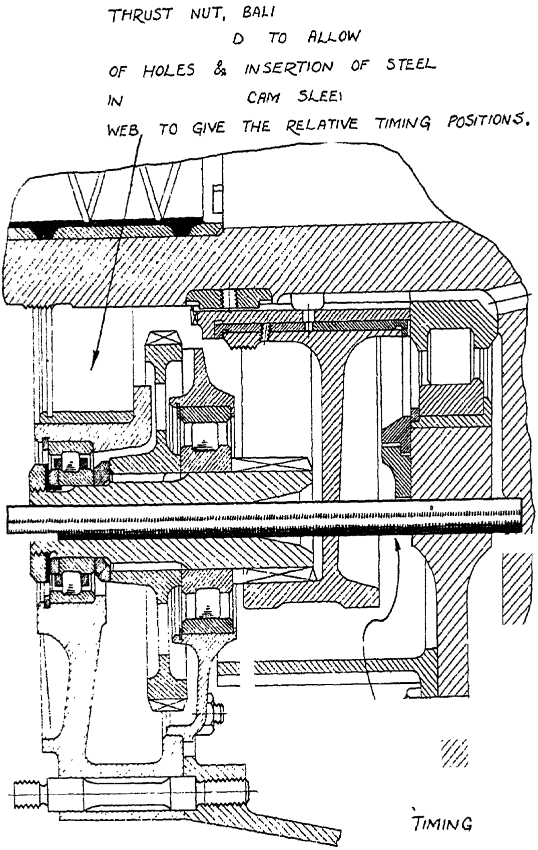


Fig. 93.—DIAGRAM SHOWING TIMING BAR IN POSITION.

Assemble cone mounting to stand.

2. Fit tab washers to crankcase bolts. Assemble rear half crankcase to cone mounting, with No. 1 aperture aligned with lifting link, and fit crankcase bolts (Fig. 85).

3. Suspend crankshaft assembly from jib (Fig. 86) and assemble ring rollers on crankshaft inner races; retain in position with rubber d (Fig. 87).

4. Align No. 6 aperture with master rod and position articulated rods in line with their respective apertures. Guide crankshaft assembly into position. (The rubber band will be displaced and should be removed.)

5. After applying jointing compound to joint faces, assemble front half crankcase, ensuring that front and rear sump joint faces are in line. Fit tab washer and nut to each bolt and securely tighten and lock. Remove jib and front rubber ring.

6. Commence by fitting No. 6 piston and cylinder. Evenly space the gas and scraper ring gaps and place piston over master rod "eye"

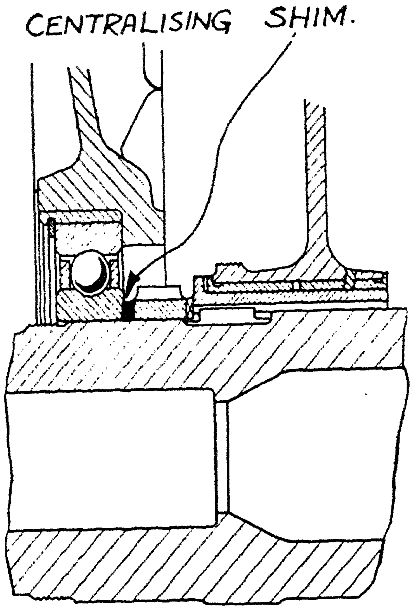


Fig. 94.—DIAGRAM SHOWING POSITION OF CONNECTING ROD ASSEMBLY CENTRALISING SHIM.

with cylinder numeral on gudgeon pin boss, towards front of engine. Insert gudgeon pin, assemble rings and fit new circlips, using tools provided. Check circlips for security and ensure gudgeon pin is free to rotate (Fig. 88).

7. Fit new rubber ring to the cylinder spigot and apply engine oil. Compress piston rings, using tool provided (Fig. 89), and assemble cylinder. Fit tab washers and nuts and securely tighten and lock.

8. Assemble remaining pistons and cylinders in the sequence Nos. 3, 1, 8, 4, 2, 7 and 5. Do not fit No. 9 at this stage, since the aperture will be utilised for inspecting the centralisation of the connecting rod assembly.

9. Assemble oil sump in position, using new washers.

10. Fit crankshaft key ("0" towards front). Insert crankshaft sleeve in the cam sleeve bore with serrated end towards front. Fit protecting sleeve and assemble crankshaft sleeve, with cam sleeve, on to crankshaft; align keyway with key and press into position, using tools provided (Fig. 90).

11. Align one of the small holes in cam sleeve with hole in front half crankcase wall, and rotate crankshaft until blind hole in front balance weight is aligned with the two stated above. Apply jointing compound to front cover rear joint face and assemble to crankcase. Fit and tighten nuts, using suitable distance pieces.

The replacement of the cam, layshaft gear and layshaft will necessitate checking the backlash of these components. Insert tool into layshaft bore and attach dial indicator to front cover (Fig. 91). The tool arm is engraved with two separate markings, representing layshaft pinion and layshaft gear pitch lines respectively. Adjust indicator on pinion line and check backlash with crankshaft in various positions. Assemble cam drive gear on crankshaft and check backlash in the same manner (Fig. 92) after setting indicator on appropriate tool arm marking. Remove cam drive gear.

12. Insert timing bar through layshaft bore and through holes

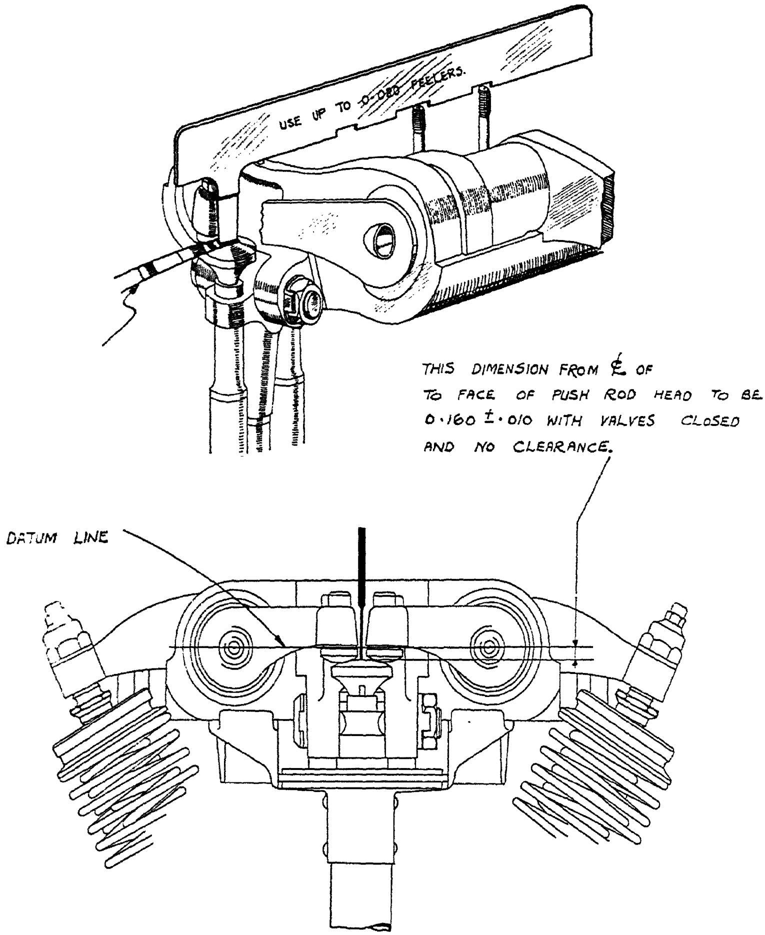


Fig. 95.—Showing application of gauge for checking rocker angle of attack.

mentioned above (Fig. 93). Centralise crankshaft movement resulting from the clearance of timing bar in holes. Observe the amount of accumulative backlash for layshaft pinion and cam sleeve teeth and position gear midway. Note position of layshaft teeth in relation to the serrations on crankshaft sleeve and select on the cam drive gear a position to correspond. Insert gear into position, ensuring that backlash is not taken up in either direction.

13. Fit centralising shims (if any) (Fig. 94) and press the front journal aring into position, using the appropriate tools. Fit retaining ring, tab er and crankshaft locknut.

14. Observe the centralisation of the gudgeon pin "eyes" between

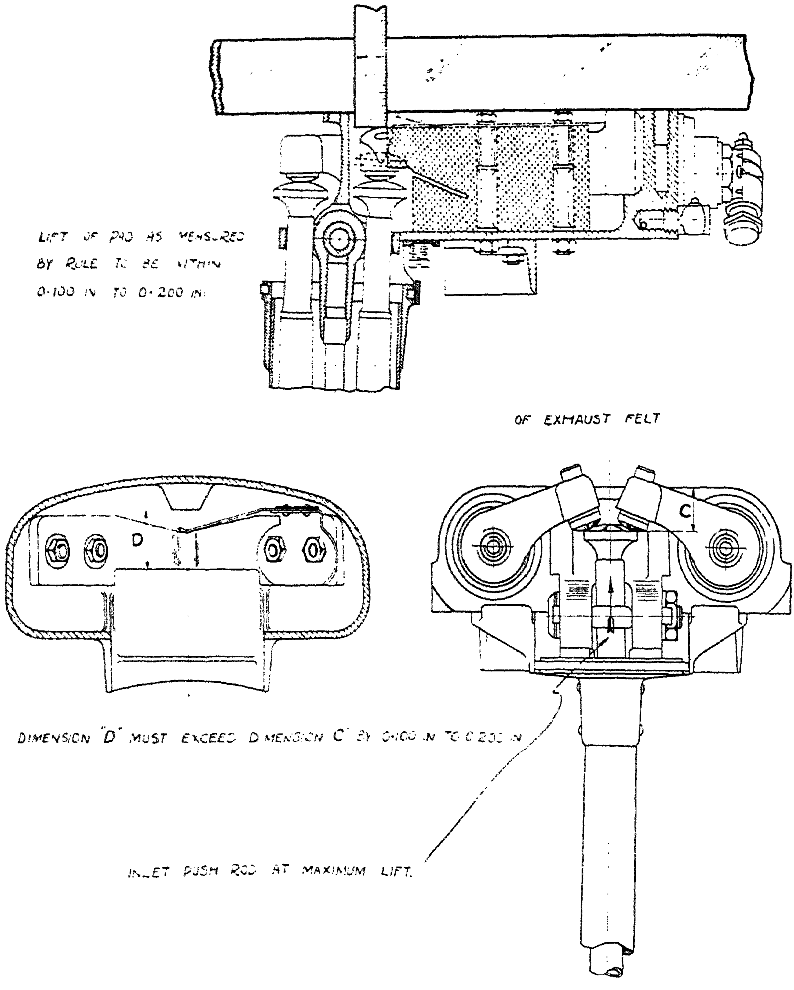


Fig. 96.—DIAGRAM SHOWING METHOD OF CHECKING LIFT OF ROCKER MECHANISM FELT PADS.

the internal faces of their piston bosses; the "eyes" should be central. If satisfactory, lock crankshaft nut.

15. Assemble No. 9 piston and cylinder.

16. Fit rubber ring to each tappet guide; apply oil and assemble each guide and tappet complete to its appropriate bore.

17. Fit tappet guide packing pieces in position and assemble push rod unit complete over studs; fit the tab washers and nuts. Slacken back rocker adjusting screws and swing rocker unit downward. Whilst

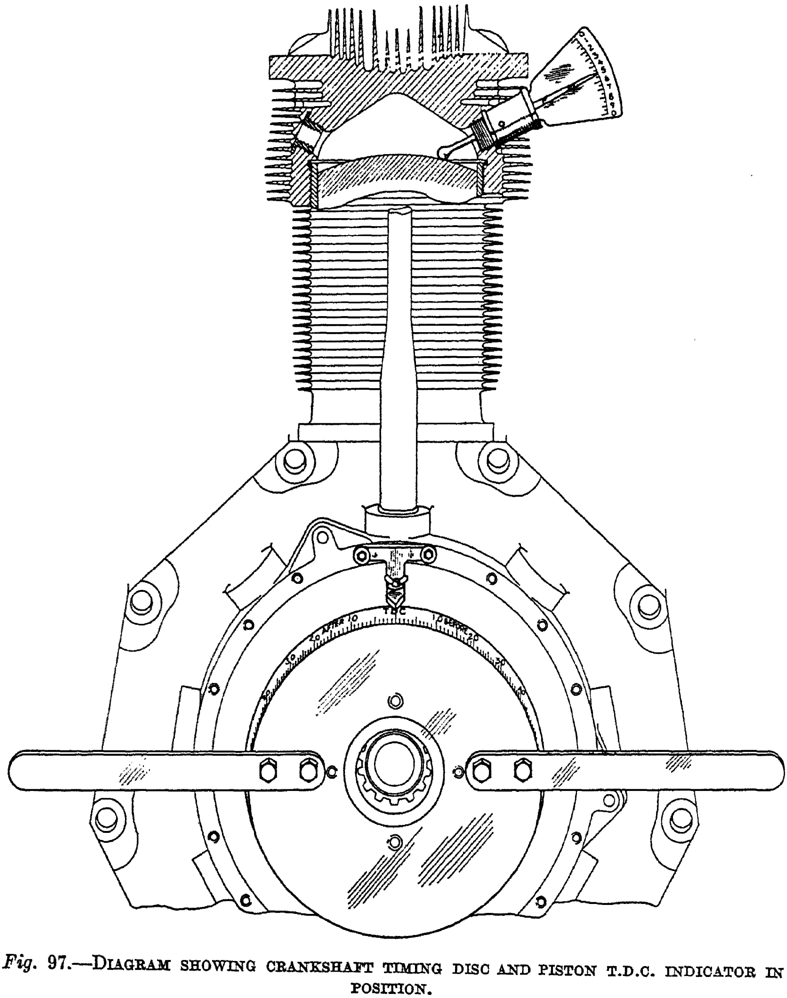


Fig. 97.—DIAGRAM SHOWING CRANKSHAFT TIMING DISC AND PISTON T.D.C. INDICATOR IN POSITION.

rocker unit is being lowered over tie rod eye, both inlet and exhaust push rod heads should be guided into push rod upper ends.

18. Insert tie rod bolt, using tool provided, and fit tab washer and nut.

19. Check angle of attack of both inlet and exhaust rockers as follows : ensure that push rod heads are seating firmly on their hardened steel bases. Turn crankshaft until piston of cylinder concerned is on T.D.C. firing stroke. Unscrew rocker adjusting screws to their full extent. Place gauge on rocker bracket, with blade projecting downward between the two inlet rockers (Fig. 95). The clearance between push rod head and

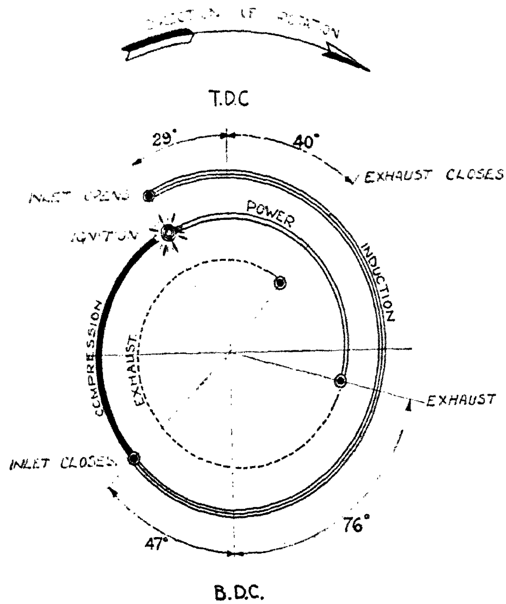


Fig. 98.—VALVE TIMING DIAGRAM.

gauge blade is determined by feeler gauges, the measurement obtained giving the setting of the push rod head in relation to the datum line, which is a line joining the centres of the two rocker shaft assemblies (Fig. 95).

If no feelers can be inserted, the low limit of 0·150 in. is indicated between push rod head and rocker button. Where feelers can be inserted between gauge blade and push rod head, the resulting clearance is a direct measure of the number of thousandths of an inch that push rod lies below datum line ; the maximum permissible limit is 0·170 in.

Where the "low" limit is exceeded, the push rod lower ends are to be removed, and push rod tube length reduced the required amount. If the "high" limit is exceeded, it will be necessary to replace existing push rods with longer ones. The length of tie rod should not be altered. On conclusion of this check, lock tie rod bolt nut and tie rod bracket stud nuts.

20. All felt pads are to be soaked in oil, Specification D.T.D.109 (Mineral) at a temperature of 50° C. for a minimum period of one hour. (The inlet pad need not be removed from the rocker cover.) Fit the exhaust felt pads to their respective cylinders. When fitting new inlet and/or exhaust felt pads, careful check must be made to ensure that the total lift of each pad is within the limits of 0·100 in. to 0·200 in. (Fig. 96).

Assemble felt pads in valve upper washers, followed by retainers and circlips.

On later engines, fit the split felt pad on push rod cover flange.

21. Rotate crankshaft until No. 1 piston is on T.D.C. firing stroke. Set rocker adjusting screw clearance to 0·004 in. for inlet and 0·006 in. for exhaust. The clearances must be set on the highest of the four dwells between the lobes on the cam sleeve, as previously described.

22. Check valve timing on No. 6 cylinder. Fit piston indicator in spark-

ing plug hole, place timing disc on crankshaft, and fit pointer to front cover studs (Fig. 97). Determine T.D.C. firing stroke for No. 6 piston and set pointer to 0° T.D.C. line on timing disc. Recheck by rotating crankshaft 10° before and after T.D.C., noting that piston indicator readings are identical. Check valve timing in the following sequence: exhaust opening, inlet opening, exhaust closing, inlet closing; the results should conform to the timing diagram (Fig. 98).

23. Fit the two spring drive gear keys to rear half crankshaft with figures "1" and "0" towards the front. Assemble spring drive gear, employing drift provided. Fit tab washer and nut and securely tighten and lock. The replacement of either spring drive gear or one or more intermediate driving gears necessitates checking their relative positions. Place the gauge (Fig. 99) with its end faces locating squarely on cone mounting flange rear face, and adjust centre blade against side face of spring drive gear. Transfer the setting to the other gauge (Fig. 100) and place this gauge across annular joint face of the blower casing (Fig. 101). Check

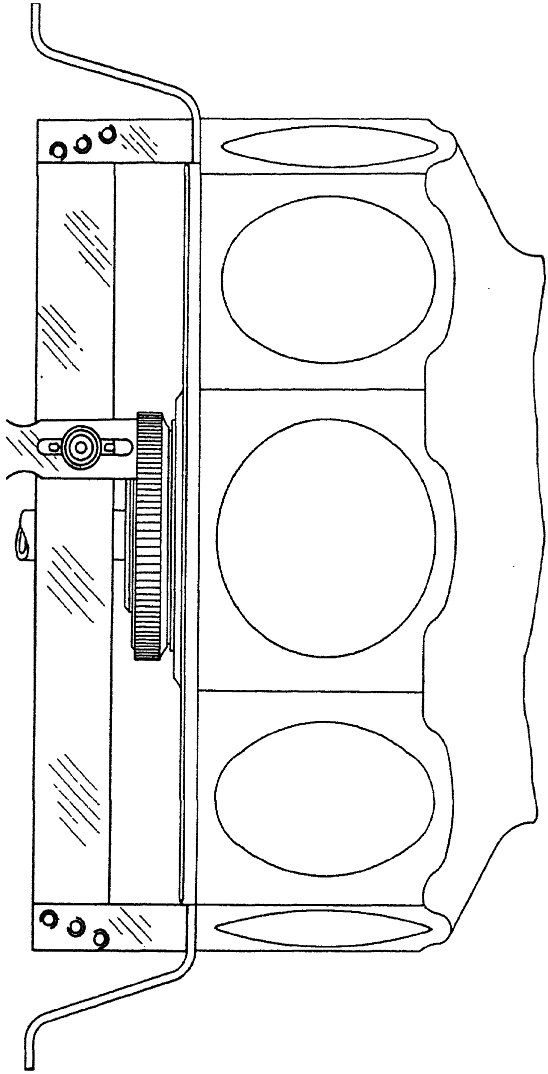


Fig. 99.—Setting gauge for checking clearance of spring drive gear.

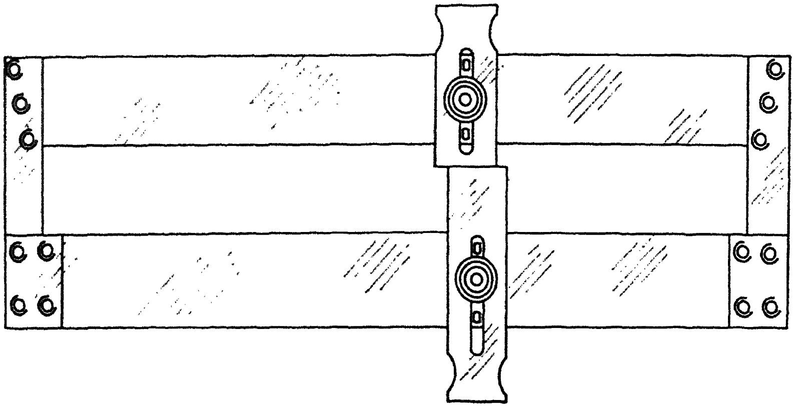


Fig. 100.—TRANSFERENCE OF GAUGE SETTING.

with feeler gauges the clearance between end face of gauge blade and end faces of intermediate gear bolts; this must not be less than 0·070 in. Place rubber ring in position on external diameter of crankcase spigot and apply engine oil. Assemble blower unit, noting that induction elbow is aligned between Nos. 5 and 6 cylinders. (Check that primer oil pipe is correctly positioned over channel in blower casing.) Fit tab washers and nuts after assembling H.T. wire clamp plate to No. 5 bolt. Tighten nuts and lock.

24. Fit rubber packing to recess in inlet pipe branches before assembling them to volute casing. Fit rubber joint rings and holders to inlet pipes before inserting each into induction elbow. Apply approved jointing compound to both sides of elbow packing and place in position on inlet port joint faces. Assemble induction elbows to cylinders.

Slide inlet pipes into pipe branches and tighten and lock the set screw in each elbow. Position upper and lower rubber rings against flange faces and secure ring holders with nuts and washers. An even

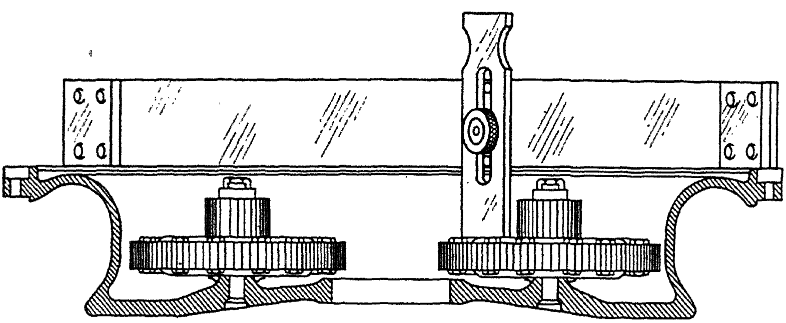


Fig. 101.—SETTING GAUGE FOR CHECKING CLEARANCE OF INTERMEDIATE GEAR.

clearance all round should exist between flanged holder faces and flanged faces of the elbow and branch pipes.

25. Assemble the priming system (three or seven cylinder) in position and secure brackets and clips to studs on branch pipes and elbows.

26. Place rubber ring over rear cover joint face spigot; apply engine oil and assemble rear cover to volute casing. Fit tab washers and nuts; tighten the latter and lock.

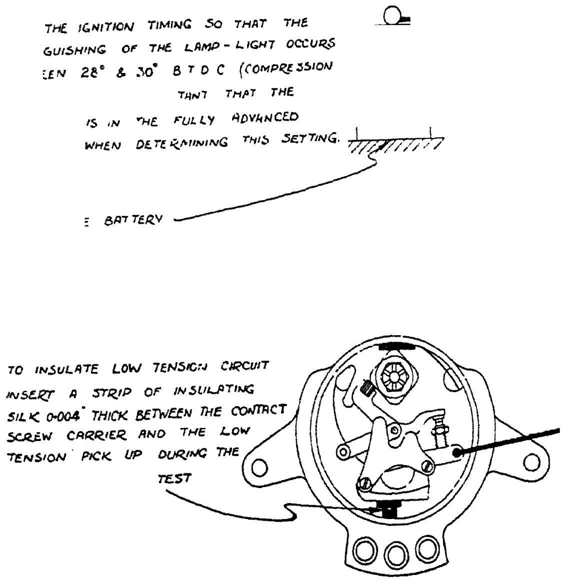


Fig. 102.—DIAGRAM SHOWING METHOD OF CHECKING IGNITION TIMING ON SINGLE CONTACT BREAKER MAGNETOS.

27. Assemble starter jaw to crankshaft tail shaft. Assemble cross drive shaft and housing and tachometer drive and housing to rear cover, followed by compressor drive casing if required.

28. Attach the lower H.T. wire supports to the branch pipes and clip the upper sleeves into position. Assemble wire clamps, progressively place wires in their correct positions and tighten nuts. Check each wire for continuity and insulation, using a lamp and battery and hand-starter magneto respectively. On later engines with Marconi harness, proceed as follows: align har-

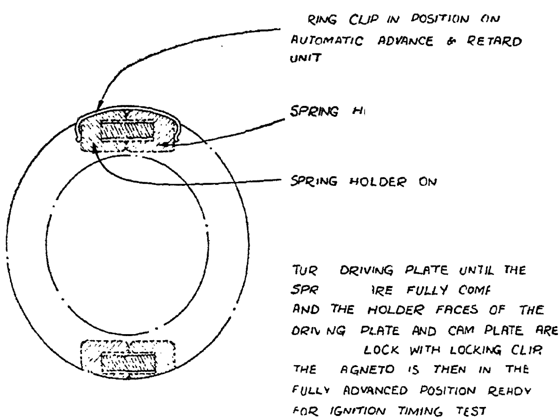


Fig. 103.—DIAGRAM SHOWING METHOD OF LOCKING AUTOMATIC IGNITION COUPLING IN FULLY ADVANCED POSITION.

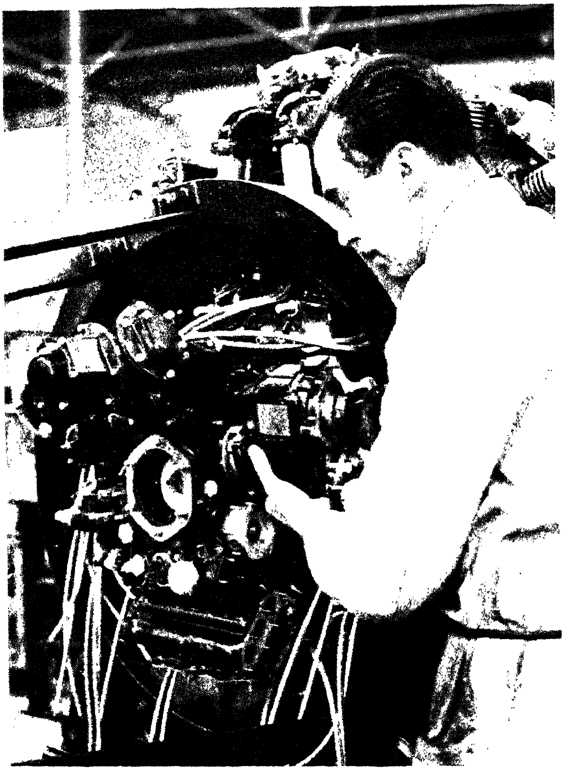


Fig. 104.—Assembling single contact breaker magneto to rear cover.

ness with No. 1 cylinder and thread cables through their respective orifices in cone mounting. Locate harness by securing retaining clips to crankcase bolts. Assemble H.T. wire supports to induction branch pipes and check wires for insulation and continuity.

29. The ignition timing for both magnetos is set on No. 6 cylinder. Using timing disc and T.D.C. indicator, determine the pointer setting for T.D.C. firing stroke as previously described. Rotate crankshaft anti-clockwise (facing front of engine) through about 40° and then clockwise until pointer indicates 29 Maintain in this position whilst subsequent operations are carried out.

Replace key in the magneto driving shaft, assemble the automatic coupling and fit tab washer and nut.

Remove contact breaker cover and insulate the low tension circuit as shown in Fig. 102. Lock automatic coupling in fully advanced position (Fig. 103). Set distributor brush slightly before No. 6 segment and breaker points about to separate. Assemble outer serrated driving plate in such a position that the dogs will mesh with the slots in magneto driving drum ; temporarily fit the nuts. Assemble magneto to the rear cover (Fig. 104) and wire the lamp and battery as illustrated (Fig. 102). Check timing on all four cam lobes ; the variation should not exceed 2 degrees. Similarly time the second magneto and check both for synchronisation.

On completion, remove magnetos, lock driving plate nuts, remove insulating silk and release automatic couplings. Apply jointing compound to both sides of magneto distance pieces and reassemble the magnetos.

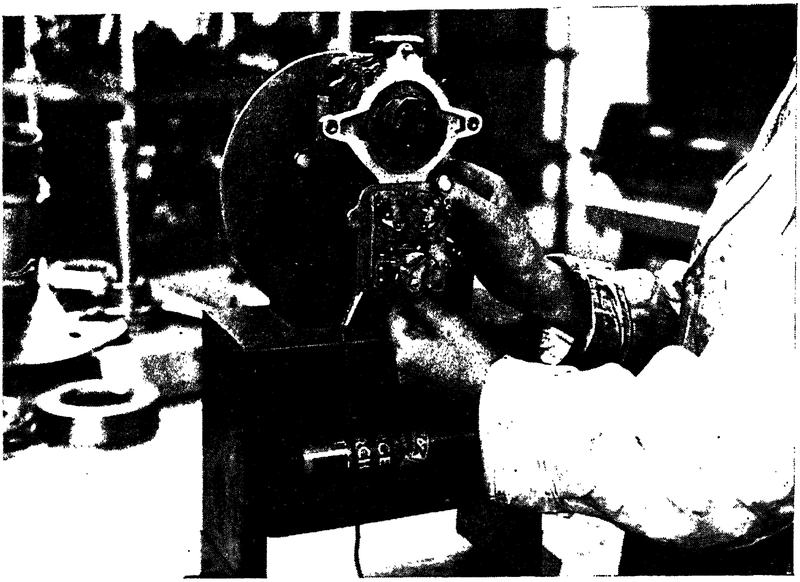


Fig. 105.—SETTING IGNITION TIMING ON DUAL CONTACT BREAKER MAGNETO.

On later engines with dual contact breaker magnetos the procedure is as follows: temporarily insulate low tension circuit by inserting insulating silk beneath brass low tension pick up and lock automatic

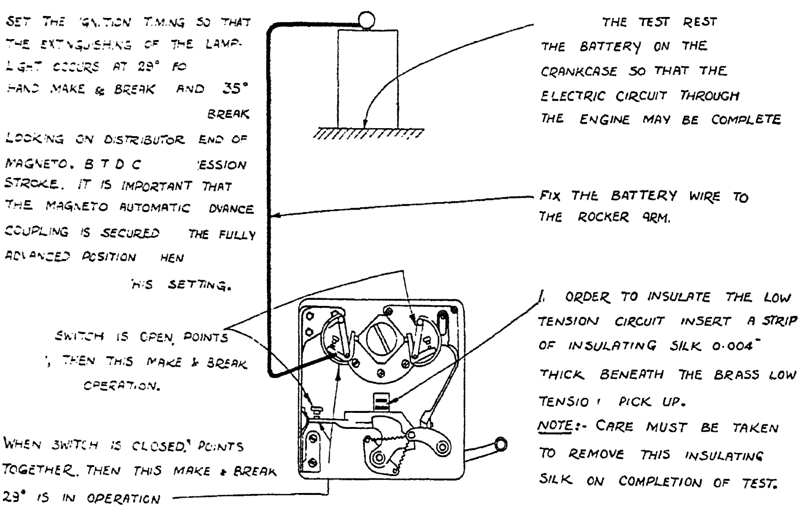


Fig. 106.—DIAGRAM SHOWING METHOD OF CHECKING IGNITION TIMING ON DUAL CONTACT BREAKER MAGNETOS.

coupling in fully advanced position. Set distributor rotor to position slightly before No. 6 segment and with contacts of left hand or retarded contact breaker just breaking (Fig. 105). Assemble outer driving plate in such a position that dogs will mesh with slots in magneto driving drum; temporarily fit the nuts. Assemble magneto to the rear cover and wire lamp and battery as illustrated in Fig. 106. Place operating switch in "off" position and check timing on all four lobes of cam on magneto rotor shaft; the variation should not exceed 2 degrees. Having satisfactorily obtained the retarded setting, transfer battery cable to right-hand or advanced rocker arm. Set this contact breaker at 35° before T.D.C. by adjusting the plate carrying the unit which is held by four set screws. Repeat the foregoing instructions on second magneto and finally check both for synchronisation. On completion, remove the magnetos, lock driving plate nuts, remove insulating silk and release automatic couplings. Apply jointing compound to magneto distance pieces and reassemble magnetos. Connect up each control tube to the intercontrol lever and magneto control lever. Fit the cross tube and synchronise the two magnetos.

30. Position engine with No. 1 cylinder vertical. Rotate crankshaft until No. 1 piston is T.D.C., induction stroke and crankshaft master spline is aligned with No. 1 cylinder. Assemble the reduction gear driving wheel, fit the lock washer and nut and securely tighten and lock. Apply jointing compound to reduction gear case joint face. Align the airscrew shaft master spline with that of the crankshaft and ensure that the marked tooth on rear bevel gear will mate between the two marked teeth on driving wheel. Assemble the reduction gear unit to the crankcase with the master spline, identification and licence plates aligned on the vertical centre line. This ensures correct positioning of oil drain holes. Fit nuts and washers. When V.P. airscrew is fitted assemble the oil pipe support bracket.

Oil Pipes

V.P. Airscrew Oil Pipes.—Fit rear oil pipe from banjo connection on No. 1 crankcase bolt to union on port side of gun gear housing. Insert front supply pipe through bush in support bracket and assemble to union on oil transfer casing and to union on No. 1 crankcase bolt.

High Initial Oil Pressure Supply.—Insert lower supply pipe through H.T. wire holder behind No. 3 cylinder and connect lower end of pipe to banjo connection on oil pump body. Fit upper pipe to nozzle between cylinders Nos. 1 and 2 and to upper end of lower pipe.

Automatic Throttle Control Pipes.—Fit upper control pipe from union on port side of control casing to volute casing and assemble lower pipe between control valve cover and volute casing.

Starter Unit

Prior to assembling starter unit, pour 1 quart of engine oil into rear cover through starter aperture.

FITS AND CLEARANCES

Notes on Application of Schedule

1. The data regarding "Fits and Clearances" are specified under three headings, *i.e.*, "minimum clearance new," "maximum clearance new" and "permissible worn clearance."

2. All clearances are given in decimals of an inch, together with a fractional suffix. The fractional suffix represents that fraction of a thousandth of an inch by which the actual clearance exceeds the decimal figure quoted. Thus a clearance given as 0·002¾ when written in full would be 0·00275 in.

3. The dimensions in the column "permissible worn clearance" represent the maximum clearance to which parts may be worn and refitted for a further period of service.

Note.—These dimensions have been so fixed that the components are fit for a full period of further service which is normally permitted between complete overhauls. When, however, parts are found during complete overhaul to be worn beyond the limits laid down, they must be discarded as unserviceable.

4. When a minus sign precedes the limit, this indicates that it is a negative clearance, *i.e.*, an interference.

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance	REMARKS
Crankshaft and Main Bearings				
Front and rear crankshaft main roller bearing outer races in housings	−0·000¾	−0·002½	—	
Roller bearings. Front and rear bearing inner race, fit of rollers between flanges	0·000¾	0·001¾	0·003	The inner races of these bearings are ground slightly taper, *i.e.*, the smallest diameter adjacent to the crank and maneton webs.
Roller bearings assembled in engine clearance on diameter between rollers and outer race.				
Front	0·003½	0·005	(See remarks)	The clearance quoted must therefore be
Rear	0·004	0·005½	(See remarks)	checked on the diameter remote from the webs.
Ball bearing at front end of crankshaft. End float between inner and outer race	0·010	0·019	0·024	
Crankshaft				
Diameter of crankpin				Minimum regrind size 0·015 below new dimension.
Ovality of crankpin				0·001½ maximum allowable.
Wobble at forward end (*i.e.*, front ball race position)				Maximum allowable, 0·004, *i.e.*, clock indicator reading 0·008.

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance	REMARKS
Crankshaft—*continued*				
Errors of alignment between shaft and crankpin, parallelism and twist when measured on crankpin between two points 3 in. apart	—	—	—	0·003, measured in two planes at 90°. Taper and ovality of crankpin to be taken into consideration when measuring.
Crankshaft tailshaft in crankshaft. Backlash between splines and splineways	—	—	0·010	Push fit when new.
End float	0·005	0·032	—	
Clearance between airscrew shaft extension and bush in crankshaft	0·003½	0·004½	0·008	
Connecting Rods				
Master rod—errors of alignment between big end bore and gudgeon pin bore, per inch of mandrel :—				
Parallelism	—	—	—	0·002
Twist	—	—	—	0·003½
Articulated rods—errors of alignment between articulated rod pin and gudgeon pin bores, per inch of mandrel :—				
Parallelism	—	—	—	0·002
Twist	—	—	—	0·003½
Big end bush in master rod. Ovality of master rod bore .	—	—	—	0·002
Clearance between bush and rod	0·000½	0·002	0·003	
Clearance between big end bush and crankpin.	0·003¼	0·004½	0·006	
Master rod assembly—end float .	0·008	0·012	—	
Big end bush, assembled in master rod—end float	0·008	0·035	0·050	
Fit of thrust ring on master rod .	0·001	0·003¾	0·005	
Master rod spigot for thrust ring. Ovality.	—	—	—	0·002½
Articulated rods and bushes. End float between master rod flanges	0·012	0·021	0·030	
Clearance between articulated rod pin and articulated rod pin bush	0·001¾	0·003	0·005	
Gudgeon Pin				
Clearance between gudgeon pin and bush	0·001	0·002	0·005	
Clearance between gudgeon pin and bore in piston . . .	0·001	0·002	0·004	
Gudgeon pin, end float in piston .	0·040	0·076	0·100	
Piston Rings				
Compression gas rings. Clearance of rings in grooves in piston .	0·006	0·007½	0·013	
Scraper rings (articulated rod pistons). Clearance of rings in top ring grooves in piston .	0·003½	0·005½	0·008	

Piston Rings—*continued*

Top scraper ring (No. 6 piston). Clearance of rings in grooves in piston	0·003	0·004½	0·008	
Bottom scraper ring. Clearance of rings in grooves in piston .	0·003	0·004½	0·008	
Top scraper rings, gap (articulated rod pistons). When in position in cylinder	0·033	0·037	0·070	
Top scraper ring, gap (No. 6 piston). When in position in cylinder	0·028	0·032	0·070	
Bottom scraper ring, gap. When in position in cylinder . .	0·024	0·028	0·070	
Compression rings, gap. When in position in cylinder . .	0·060	0·065	0·075	

Pistons

Width between gudgeon pin bosses				1·285
Maximum ovality of piston at top of skirt.			0·019 (See remarks)	Minimum diameter across minor axis = 5·708. Maximum diameter across major axis = 5·727.
Clearance between piston land and skirt diameters and cylinder when measured in centre of cylinder				Diameter of skirt parallel.
Top land . . .	0·045	0·048		
Second land . . .	0·041	0·044		
Third land . . .	0·038	0·041		
Skirt	0·028	0·031	0·038	

Tappets and Guides

Clearance between tappet, large diameter and guide, large bore	0·001	0·003	0·005	
Clearance between tappet, small diameter and guide, small bore	0·000¾	0·001¾	0·004	
Clearance between tappet roller and gap in tappet . . .	0·008	0·011	0·016	
Clearance between tappet roller bush and bore of roller . .	0·000½	0·001¾	0·004	The clearance between bush and pin when added to clearance between bush and tappet roller on any individual assembly must not exceed 0·006.
Clearance between tappet roller pin and tappet roller bush .	0·001	0·002	0·004	
Clearance between tappet roller and gap in tappet guide . .	0·003	0·008	0·016	
End clearance between tappet roller pin and large bore in tappet guide	0·012	0·018	0·030	

Cam Gear

End clearance of cam sleeve and bushes on crankshaft sleeve .	0·008	0·012	0·020

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance.	REMARKS
Cam Gear—*continued*				
Clearance on diameter between crankshaft sleeve and cam sleeve assembled with bushes	0·003	0·005½	0·008	
Crankshaft gear and layshaft gear:—				
Backlash	0·002	0·008	0·018	
Layshaft, end float	0·006	0·008	0·020	
Cam sleeve gear (internal) and layshaft gear. Backlash	0·005	0·015	0·025	
Layshaft roller bearing, large. Bearing assembled, clearance on diameter between rollers and outer race	0·002½	0·003¾	0·006	
Layshaft roller bearing, small. Bearing assembled, clearance on diameter between rollers and races	0·002¾	0·004	0·006	
Reduction Gear				
Airscrew shaft (alignment). Wobble at forward end	—	—	—	0·005, *i.e.*, clock indicator reading 0·010 at extreme end of taper.
Wobble at rear end	—	—	—	0·002½, *i.e.*, clock indicator reading 0·005.
Clearance between stub arms and pinion bushes	0·001 (Floating	0·003 bushes)	0·005 (See Note *)	* *Note.*—The clearance between bush and stub arm, when added to the clearance between bush and bevel pinion, must not exceed 0·007 in any individual assembly.
Clearance between stub arms and pinion bushes	0·001½ (Fixed	0·003¼ bushes)	0·005	
Clearance between bush and bevel pinion	0·001 (Floating	0·002 bushes)	0·004 (See Note *)	
End float of bevel pinions on airscrew shaft stub arms	0·002	0·016	0·029	
Thrust ball bearing on stub arms. End float between inner and outer races	0·003	0·008½	0·015	
Bevels, backlash—Rear	0·009	0·011	—	
Front	0·009	0·011	—	
Bevel wheels, bevel wheel driving member and anchor. Backlash between splines and splineways	0·002	0·008	0·018	
Ball bearing on front of airscrew shaft. End float between inner and outer races	0·008	0·010	0·015	
Ball thrust bearing at rear of airscrew shaft. End float between inner and outer races	0·006	0·010	0·018	
Clearance between oil seal ring grooves and oil seal rings	0·003¾	0·006¼	0·008	
Oil seal ring gap when in position in oil transfer housing liner	—	—	0·008 (See remarks)	*Note.*—Rings which on inspection are found to be within the limits of wear are to be rejected if the bearing surfaces are rough.

Reduction Gear—*continued*

Oil transfer housing liner. Bore for oil seal rings.	—	—	(See remarks)	—Liner must be carefully inspected to ensure that excessive grooving has not taken place. Maximum permissible depth of grooving that can be allowed is 0·000½, *i.e.*, 0·001 increase in diameter of bore.
Ovality of bore for oil seal rings.			0·002	

Cylinders

Cylinder bore, standard size				Maximum allowable wear 0·005 greater than new dimension.
Ovality of cylinder bore:— Measured at 2·750 from mouth of cylinder				0·008. The greatest diameter of cylinder bore, when measured in the centre of cylinder to be within "permissible worn dimension."
Measured in centre of cylinder				0·005. (See above remarks.)

Valves and Guides

Clearance between inlet valve stem and inlet valve guide bore .	0·001½	0·003½	0·008	(Measured up to 0·500 from outer end.)
Clearance between exhaust valve stem and exhaust valve guide bore	0·003	0·005	0·010	(Measured up to 0·500 from outer end.)
Valve, inlet, ovality of stem .	—	—	—	0·001
Valve, exhaust, ovality of stem .	—	—	—	0·001½
Valve guide, inlet, ovality of bore up to 0·500 in. from outer end .	—	—	—	0·004
Valve guide, exhaust, ovality of bore up to 0·500 in. from outer end	—	—	—	0·005
Clearance between under face of lower inlet valve spring washer and cylinder head . . .	0·030	0·050	—	
Clearance between under face of lower exhaust valve spring washer and cylinder head .	0·040	0·060	—	
Fit of valve guides in cylinder head	−0·001	−0·002	—	
Valves, regrinding. Valves, inlet and exhaust, minimum thickness of valve head after regrinding valve face (*i.e.*, dimension from top of valve head to top edge of valve face) . .	—	—	—	0·050

Valve Springs

Inner spring: Length with valve open . . .				1·344
Inner spring: Load with valve open . . .	23 lb.	27 lb.	20 lb.	

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance	REMARKS

Valve Springs—*continued*

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance	REMARKS
Intermediate spring. Length with valve open	—	—	—	1·344
Intermediate spring. Load with valve open	43 lb.	47 lb.	37 lb.	
Outer spring. Length with valve open	—	—	—	1·344
Outer spring. Load with valve open	63½ lb.	67½ lb.	57½ lb.	

With the valve springs assembled in the cylinder, the maximum permissible length of outer valve spring with valve in closed position is 1·870 under any conditions. If, on checking, this dimension is found to be exceeded, special valve spring washers, giving additional compression to the valve springs, must be fitted, in order to maintain the valve spring length within this specified limit.

Rocker Gear

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance	REMARKS
Clearance between rocker bracket bolt and bush in rocker bracket, also tie rod eye	−0·000½	+0·000½	—	
Clearance between sleeve on trunnion and bore in cylinder lug	−0·000¼	+0·000½	—	
Clearance between cylinder lug face and face of washer	0·011	0·015	—	
Clearance between push rod head stem, and bore of push rod upper end	0·001½	0·002¾	0·006	
Clearance between push rod upper end and guide holes in tie rod.	0·005	0·008½	0·025	

Supercharger

PARTS AND DESCRIPTION	Clearances New Minimum	Clearances New Maximum	Permissible Worn Clearance	REMARKS
Clearance between oil seal rings in retainer ring grooves	0·002	0·004½	0·006	
Gap when in position in volute casing cover sleeve	—	—	—	0·040
Driving gears. Backlash between spring drive gear and intermediate gear pinions	0·006	0·010	0·018	
Backlash between intermediate gear and impellor gear	0·008	0·010	0·016	The final setting of the backlash to be relational and must not vary more than 0·002 for each set of gears.
Impellor. Wobble, measured at sides of blades, at their outer ends				0·005. Measured with impellor gear pressed toward the rear of the engine.
Side clearance between impellor and volute casing, measured at tip of blades	0·068	0·081		
Side clearance between impellor and blower casing measured at tip of blades	0·015	0·026½		Measured with impellor gear pressed toward the front of the engine, 0·015 minimum allowed.
Clearance between vane disc and volute casing	0·025	0·035		

Supercharger—*continued*

Intermediate driving gears, roller bearings. Diametral clearance, clearance between rollers and outer race when checked in assembled condition . .	0·000¾	0·001½	0·002
End float measured in assembled condition	0·010	0·014½	0·025
Intermediate driving gear, clutch block side plates, fit on driving centre. Clearance between hub diameter of intermediate gear driving centre, and bore of intermediate gear assembled with side plates	0·002½	0·003¾	0·008
End float measured in assembled condition	0·002	0·003½	0·020
Spring drive gear on driving centre. Diametral clearance between bore of spring drive gear and driving centre spring drive plates	0·004	0·006¼	0·008
Spring drive gear on driving centre. Side float of inner ring of spring drive gear in slot in driving centre	0·005	0·008	0·012
Impellor rear ball bearing. Fit of outer race in bearing housing .	0·001½	0·002½	0·004
Impellor front ball bearing. End float between inner and outer races when measured in position	0·007	0·008	0·012

Crankcase Rear Cover

Working clearance between crankshaft tail piece and tail bearing in rear cover	0·001¾	0·003¾	0·006

Magneto Drives

Magneto drive bevels. Backlash between any pair . . .	0·002	0·008	0·014
Clearance between stub spindle and bore of bush assembled in spring drive unit . . .	0·000½	0·001¾	0·004
End float of spring drive unit assembly	0·003	0·008	0·014
Clearance between bevel wheel (driven) assembly and bore of bevel gear bearing assembled in casing	0·001½	0·003	0·006
Bevel wheel assembly in bearing—end float	0·002	0·006	0·012
Clearance between driving dog on magneto coupling and slot in bevel wheel assembly . .	0·004	0·009	0·021
Clearance between outside diameter of spring drive centre and bush assembled in bevel gear .	0·000½	0·002¼	0·005
Bevel gear assembled with bush-end float	0·001	0·005	0·010

Tachometer, Oil Pump and Fuel Pump Drives

Parts and Description	Clearances New		Permissible Worn Clearance	Remarks
	Minimum	Maximum		
Clearance between layshaft, oil pump driving dog end and bore of bush assembled in casing .	0·000½	0·001¾	0·004	—
Ball bearing on cross drive layshaft. End float between inner and outer races . . .	0·004	0·006	0·008	—
Layshaft, end float . . .	0·006	0·013	0·017	—
Clearance between outside diameter of tachometer spindle and bore of casing . . .	0·000½	0·003	0·006	—

Auxiliary Drives

Parts and Description	Minimum	Maximum	Permissible Worn Clearance	Remarks
Layshaft in rear cover driving layshaft in auxiliary drive casing. Clearance between layshaft small end, outside diameter and bush assembled in bore of casing	0·000½	0·001¾	0·004	
Layshaft in rear cover driving layshaft in auxiliary drive casing. Clearance between layshaft, large end, outside diameter and bush assembled in bore of casing	0·000½	0·001½	0·004	
Layshaft end float	0·004	0·016	0·025	
Spur wheels, backlash. Spur wheel on crankshaft, spring drive spur wheel on stub spindle and spur wheel on layshaft in rear cover.	0·004	0·008	0·014	
Layshaft in auxiliary drive casing. Clearance between layshaft, front end outside diameter and bush, assembled in bore of casing	0·000½	0·001½	0·004	
Layshaft in auxiliary drive casing. Layshaft ball bearing, end float between inner and outer races .	0·002	0·004	0·007	
Spur wheels, backlash. Spur wheel on rear cover, layshaft and spur wheel on auxiliary drive casing layshaft	0·004	0·008	0·014	

Automatic Cam Advance Gun Gear

Parts and Description	Minimum	Maximum	Permissible Worn Clearance	Remarks
Bevel on rear cover layshaft and bevel on gun gear vertical driving spindle, backlash . .	0·004	0·008 (See remarks)	0·012	Adjustable by laminated shims situated under gun gear casing and auxiliary drive casing.

Oil Pump

Parts and Description	Minimum	Maximum	Permissible Worn Clearance	Remarks
Oil pump driving spindle in bearings. Clearance between large diameter of driving spindle and bore in pump front cover .	0·000½	0·002	0·004	
Oil pump driving spindle in bearings. Clearance between driving spindle, small diameter and bore of scavenge pump casing. .	0·000½	0·001½	0·004	

Oil Pump—*continued*

Working clearance between driving dog on layshaft and slot in oil pump driving spindle .	0·007	0·021	0·040	
Clearance between bore of driven gear wheels (scavenge and pressure) and outside diameter of floating bushes	0·000½	0·002	0·004	
Clearance between driven wheel spindle and bore of floating bushes	0·000½	0·002	0·004	
End float between gear wheels (scavenge) and pump casing .	0·000	0·002	0·006	
End float between gear wheels (pressure) and pump casing .	0·001	0·003	0·006	
Clearance between gear wheels, scavenge and pressure and bore of pump casing	0·003	0·005	0·010	
Pump wheels, suction and delivery, backlash	0·010	0·012	0·016	

Generator Drive

Driving shaft front ball bearing. End float between inner and outer races	0·002	0·004	0·007	
Bevel gears. Backlash . .	0·002	0·008	0·014	Adjusted by laminated shims.
Driven gear ball bearing. End float between inner and outer races	0·002	0·004	0·007	

Romec Vacuum Pump Drive

Pump drive ball bearings. End float between inner and outer races	0·004	0·006	0·008	
Bevel gears. Backlash . .	0·002	0·008	0·014	Adjusted by laminated shims.

B.T.H. Type Air Compressor Drive (High Pressure)

Compressor drive ball bearings. End float between inner and outer races . .	0·002	0·004	0·007	
Bevel gears. Backlash	0·002	0·008	0·014	Adjusted by laminated shims.

R.A.E. Air Compressor Drive (Low Pressure)

Compressor drive ball bearings. End float between inner and outer races	0·004	0·006	0·008	
Bevel gears. Backlash . .	0·002	0·008	0·014	Adjusted by laminated shims.

Rotoplunge Pump Drive

Pump drive ball bearings. End float between inner and outer races	0·004	0·006	0·008	
Bevel gears. Backlash . .	0·004	0·008	0·014	Adjusted by laminated shims situated under pump drive casing and auxiliary drive casing.

We are indebted to the Bristol Aeroplane Co. and Imperial Airways Ltd. for assistance in connection with the preparation of certain photographs which accompany this article.

ENVOY REPAIR SCHEME

By G. A. Little, B.A.

THESE notes on the repair of the Envoy type aeroplane are divided into sections dealing with the major components, these sections being themselves sub-divided according to the type of damage sustained, the three classes being negligible damage, minor damage and major damage, depending on its extent and location.

The repair scheme is intended to cover only the primary structure, repairs to the secondary structure and equipment being left to the discretion of the operator.

Note. It is of the utmost importance that when using glue to effect any of the repairs outlined herein, a casein type glue be used and not a synthetic resin type, owing to chemical action between the two types during the setting of the latter.

FUSELAGE (INCLUDING FIN)

A. Longeron and Strut Repairs

1. Negligible Damage

Damage consisting of a bruise not greater than 0·1 in. deep by 1 in. long and 0·5 in. wide or damage such that the affected part can be cut away to leave a clean surface within the limits quoted above, is negligible whenever it may occur throughout the length of the longerons, provided that no two such places occur within 18 in. of one another.

2. Minor Damage

Damage of the same nature as that quoted above, but extending up to 0·25 in. deep by 3 in. long and 1 in. wide, is classed as minor damage and must be repaired. A typical repair of this nature is illustrated in Fig. 1. The affected portion is cut away so as to leave a clean smooth hole, without sharp corners, which is then filled with a piece of spruce, shaped to suit. A lamination of spruce, 0·2 in. thick, at least 2 in. longer than the spruce insert and the full width of the longeron is glued over the area to complete the repair.

3. Major Damage

Damage greater than that covered by the two previous classes entails renewal of the portion of longeron or of the complete strut. There is no major repair for the struts and stiffeners in the fuselage. If they suffer damage beyond that capable of being dealt with under minor repairs, then they must be replaced. A typical longeron repair is illustrated in Fig. 2, a new section of longeron being inserted, the end joints of the inserted section being made with standard 9 to 1 splices. The sides of

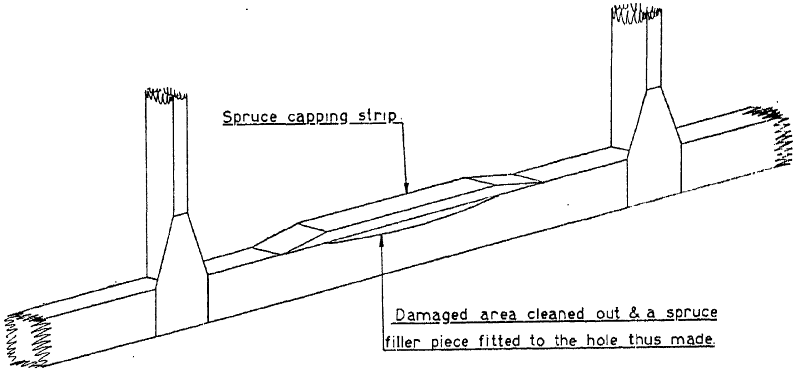


Fig. 1.—LONGERON MINOR REPAIR.

the splice on completion, must be sealed with $1\frac{1}{2}$ mm. or $\frac{1}{16}$ in. ply strips, the width of the longeron and extending along the longeron for 1 in. at each end clear of the splice. A section of longeron of any length may be inserted by this means, provided the joints are so positioned that the splices are clear of struts or stiffeners.

B. Ply Skin Repairs

Throughout this section a panel of ply is defined as the portion of ply lying between any longerons or stiffeners forming a complete boundary.

1. Negligible Damage

Damage in the form of a clean hole not more than 0·5 in. diameter or which can be cleaned out to give such a hole, is negligible provided that is does not occur within 1 in. of the boundary members of the panel. There must not be more than two such holes in any one panel nor must they be within 5 in. of one another. Damage in this category should have the edges trimmed to leave a clean hole, and then, if on the outer surface, should be covered with a doped-on fabric patch.

2. Minor Damage

Damage of a similar nature to that quoted in paragraph 1, but up to 2 in. diameter, is considered to be minor damage and must be repaired by means of a simple patch. Clean out the affected part to leave a regular shaped hole and apply a 3-ply patch of the same thickness as the ply being repaired, but 1 in. larger all round than the hole. Where the damage is in the outer skin, this patch should be placed on the inside, and another piece of ply, shaped to fit the hole, fitted so as to leave a smooth surface. A typical repair of this nature is illustrated in Fig. 3. Where the damage occurs on a bulkhead, the patch may be on whichever side is most convenient.

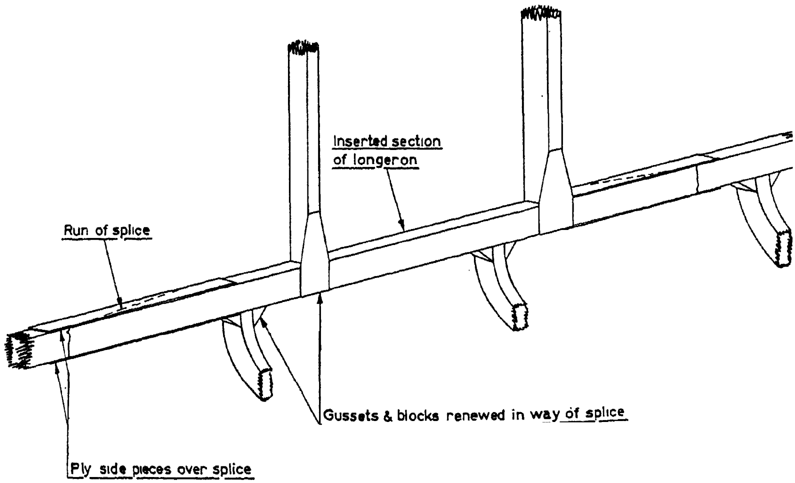


Fig. 2.—LONGERON MAJOR REPAIR.

3. Major Damage

Damage greater than that described above calls for renewal of the panel affected. Cut away the complete panel out to the boundary members and feather the edges. Prepare a new panel of ply of the same thickness as the existing ply, with the grain running in the same direction and feather the edges to fit the feathered edges of the standing portion of the ply. The panel is then glued and bradded into position. In this connection it is preferable to use thin spruce tacking strips when fixing the new panel in position, a better joint being obtainable by this means than by direct bradding. An additional advantage is that when the glue has set, the brads are removed with the tacking strips. After removal of the tacking strips, clean up the edges of the patch and finish off by painting to match the surrounding portions.

C. Fin Structure Repairs. Rib Repairs

1. Negligible Damage

No damage to the ribs, either to booms or braces, may be considered negligible. Further, bracing members must be replaced if damaged, no repairs being permissible.

2. Minor Damage

Damage affecting only one member of the composite booms, either flange or web, and at only one point in any free length, may be repaired by reinforcing the boom, as indicated in Fig. 4A. A piece of spruce, of thickness sufficient to build the web up level with the flange, is applied each side of the web in the form of a splint, these pieces being shaped to suit the true contour of the boom at the particular point. The splints

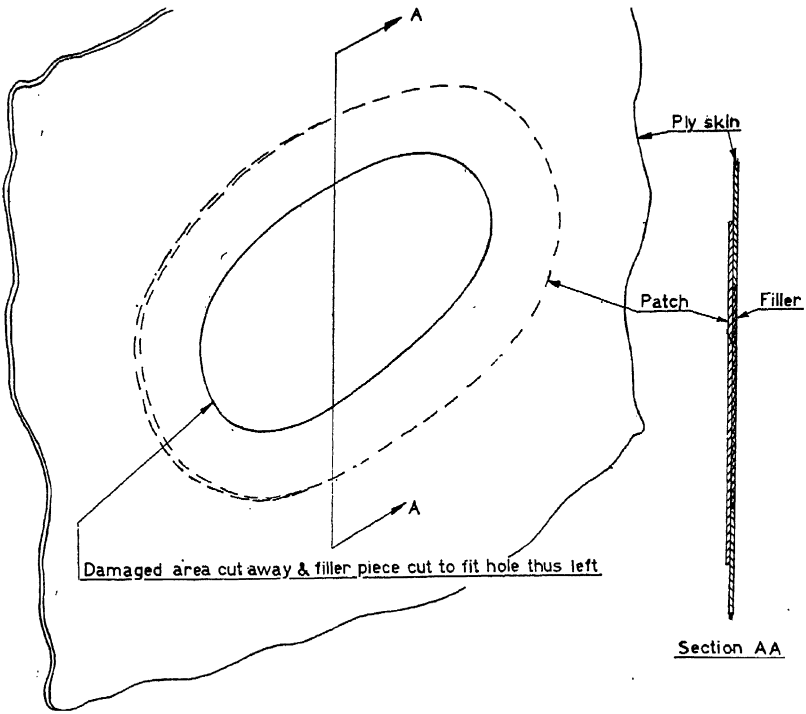


Fig. 3.—FUSELAGE SKIN MINOR REPAIR.

must extend at least 2 in. clear of the damaged area at each end, being tapered off over the final inch, the complete joint finally tightly bound with glued tape or fabric.

3. Major Damage

Damage affecting both flange and web or either at more than one point in any free length of boom, calls for replacement of the affected portion. Cut out the damaged piece for a minimum length of 2 in. and taper off the flanges for a standard splice. Fit a new section of spruce flange, tapering the ends to fit the existing portions of rib and glue in position. Shape a new piece of web, butting the ends, to suit the contour of the flange, glue in position and joint the ends with a piece of $1\frac{1}{2}$ mm. or $\frac{1}{16}$ in. ply each side, such pieces of ply to be 2 in. long. When fitting the new portion of web, it is not necessary to make a good butt joint—a gap of up to 0·05 in. being permissible. An insertion repair of this type is illustrated in Fig. 4B.

D. Fin Spar Repairs

1. Negligible Damage

Damage in the form of a bruise, not exceeding $1 \times 0{\cdot}5 \times 0{\cdot}05$ in.

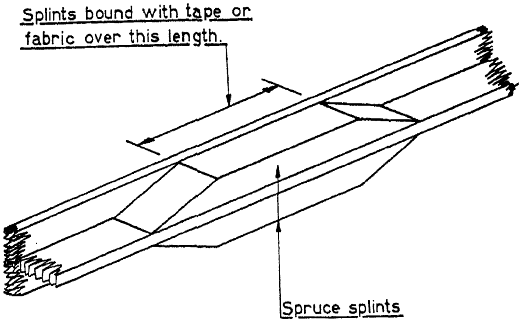


Fig. 4A.—RIB BOOM MINOR REPAIR.

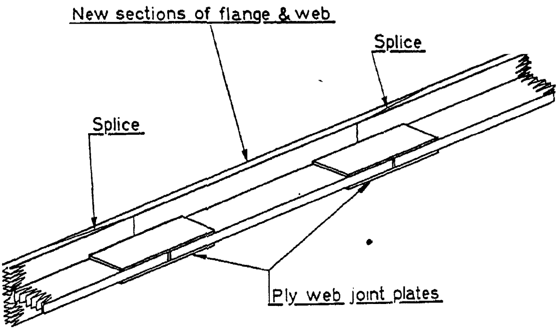


Fig. 4B.—RIB BOOM MAJOR REPAIR.

deep, in either spruce flange or ply web, is negligible, provided it does not occur within 1 in. of any metal fitting, measured along the spar from the widest part of the fitting.

No damage to the fittings themselves is negligible.

2. Minor Damage

Damage of a similar nature to that described in paragraph 1, but extending up to 2 × 1 × 0·1 in. deep, should be repaired in the manner illustrated under Longeron Minor Repair, Fig. 1, and described on p. 626, for the spruce flanges and by the addition of a $1\frac{1}{2}$ mm. or $\frac{1}{16}$-in. ply patch for the ply webs. This patch must extend the full width of the spar and at least 1·5 in. along the spar at each end clear of the damaged area. Where such damage occurs within 1·5 in. of a rib, the repair patch should be carried beyond the rib for 1·5 in., thus bringing the rib attachment into the repair portion of the patch.

3. Major Damage

Damage greater than that covered by paragraphs 1 and 2 above calls for complete replacement of the damaged portion.

(*a*) *Flange Repair.* Cut away the damaged portion of flange to within between $\frac{1}{2}$ in. and $\frac{3}{4}$ in. of the nearest internal member clear of the damaged area. If the webs have not been damaged, clean out the flange carefully, leaving the webs standing. Trim the ends thus left ready to take a 9 to 1 splice and prepare a length of spruce, the same thickness as the flange, to fit accurately the gap. Glue this in position, well clamping till the glue has set. If more convenient, the web on one side may be removed at the same time and replaced in accordance with paragraph (*b*) below. (See Fig. 5.)

(*b*) *Web Repair.* Cut away the damaged area of web over the full width of the spar back to the nearest internal member clear of the damage on each side. Trim the ends of the standing portions to make a feathered joint and prepare a new piece of ply of the same thickness and type as the original ply, feather the ends to fit the standing portions. Care should be taken to see that the grain of the patch is running in the same direction as the rest of the spar ply. Glue this patch in position, securing with either clamps or tacking strips till the glue has set.

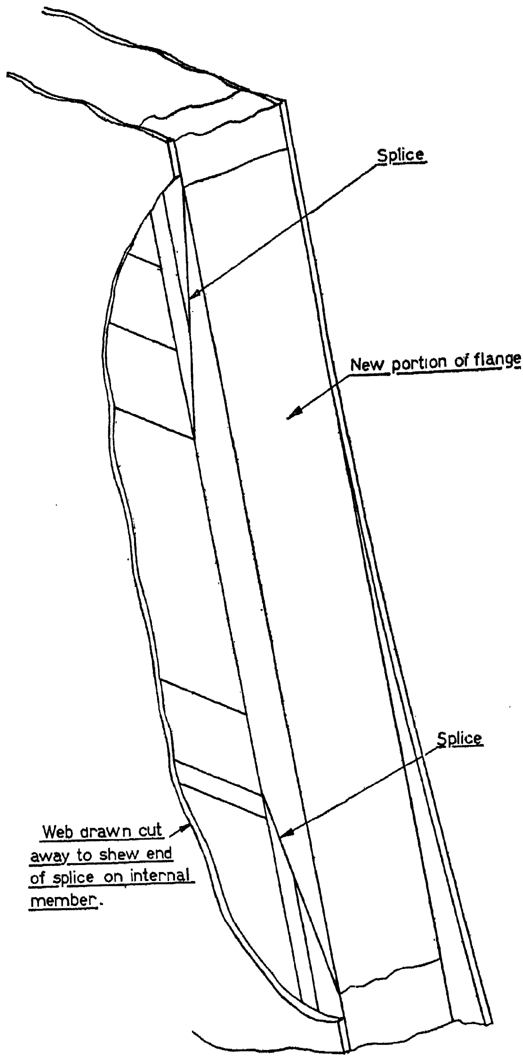


Fig. 5.—FIN SPAR REPAIR.

CENTRE SECTION REPAIRS

A. Spar Repairs

1. Flange Repairs

Negligible Damage. Damage consisting of a bruise not more than 0·1 in. deep by 1 in. diameter, or which can be cleaned out to leave a smooth surface within the above limits, is negligible wherever it may occur, provided that no two such places occur within 18 in. of one another.

Minor Damage. Damage to the surface of the flange up to 0·5 in. deep and extending to the full width of the spar must be repaired by means of an insertion and reinforcement, as illustrated in Fig. 6. A repair of this nature may be of any length and positioned anywhere in

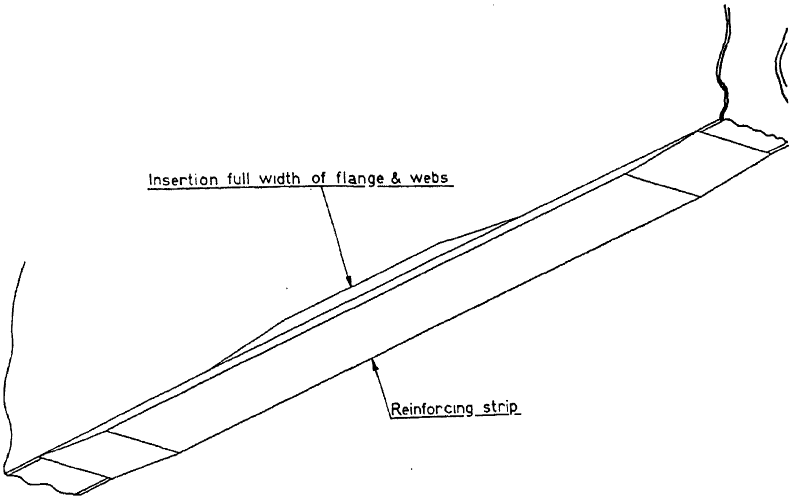


Fig. 6.—SPAR FLANGE MINOR REPAIR.

the length of the spar excepting the outer 20 in. each end of each flange, in the area of the tapered walnut blocks. Cut away the damaged area of the flange to the minimum depth within the 0·5 in. limit necessary to remove all trace of the damage, taper off the ends to run out at a 1 in 9 angle. Prepare a piece of spruce accurately to fit the recess and glue in position. Over this filler place a length of spruce 4 in. along the spar clear of the end of the filler piece, glued in position.

Major Repairs. Damage greater in extent than can be covered by the minor repair quoted above calls for renewal of a complete section of the flange, making a standard 9 to 1 splice to the sound portion of spar. A splice joint of this nature may only be made in the flanges between the inner engine rib and the fuselage side, that is, between the limits of 31 in. and 66 in. measured from the CL of the pins at the centre to extension plane joint. Effectively, each flange is thus divided into three replaceable sections. In the original design, both top and bottom spar flanges are made laminated, but when replacing under this repair a section outboard of the fuselage side, a solid flange may be used if desired. In the centre portion, however, across the fuselage, the replacement flanges must, owing to their curvature, be laminated as in the original design. To replace a portion of flange, cut away the spar webs on one face, back to the first internal member clear of the end of the proposed splice in the flange, as illustrated in Fig. 7. Which web to cut away is immaterial and must be decided by convenience. Cut away the damaged portion of flange and trim the end of the standing portion to form a 9 to 1 splice.

It is most important that the face of the splice lies in the plane, indicated in Fig. 7, so that the edges are sealed by the ply webs. Prepare

a new section of spar flange, shaping off the end accurately to fit the already prepared end of the standing portion. Replacement portions of the flanges, with the ends left long for fitting, can be supplied ready-made if required. Fit the replacement portion in position, trim or pack the internal members as necessary to fit the new piece of flange, replacing any members which may be damaged. Then glue the new portion in position, keeping it well clamped till the glue has set.

Chamfer off the standing edge of the web ply, clean off the joints between internal members and the new portion of flange to give a level seating for the new portion of web, prepare and glue this in position, clamping well till the glue has set.

The web ply on the front spar is $4\frac{1}{2}$ mm. thick, that on the rear spar $\frac{1}{8}$ in. thick, both being of the double thickness centre lamination type, with the grain set at 45° to the spar datum. It is most important that the ply used in a spar repair of this nature be of the same type as the original. If the damage to the flange involves damage to both webs, the second web may be repaired locally, as described under Spar Web Repair, or as a whole in a manner similar to that described for the panel removed in order to make the repair to the flange.

In both cases, the splice between new and original ply must not be made on the same internal member as the splice on the other face. Re-assemble and drill the spar for the various fittings, positioning where possible from the existing holes in the original spar web, using the fittings themselves as templates where necessary.

2. Web Repairs

Negligible Damage. Damage in the form of a clean hole not more than 0·5 in. diameter, or which can be cleaned out to leave such a hole, is negligible, provided that it does not occur within 1 in. of the edge of the spar flanges or internal stiffeners and not more than one such hole in any one panel of ply.

Minor Damage. Damage of a similar nature to that described above, but extending up to 2 in. diameter, if in the central area of a panel or to within 1 in. of the edges of the spar flanges or internal stiffeners, must be repaired by patching. Clean out the damaged area to leave a smooth edged regular-shaped hole, prepare a patch $1\frac{1}{2}$ in. larger than the hole all round of $\frac{1}{8}$ in. thick ply for the front spar, and 2 mm. ply for the rear spar. Chamfer off the edges of the patch over the outer 0·5 in. down to the thickness of 1 lamination, glue and brad the patch into position.

Major Damage. Damage to the webs greater than that covered by the minor damage section above, calls for complete replacement of a portion of the web. Remove the damaged area, cutting it away to the nearest internal member clear of the damage each side, and out to the extreme edges of the spar. Feather the edges of the standing portions of the web and splice in a new piece of web. The ply used for the front

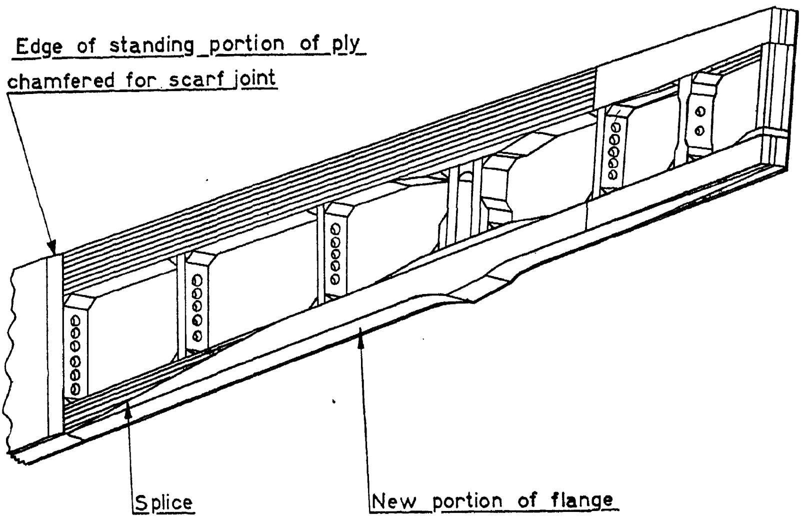


Fig. 7.—SPAR FLANGE MAJOR REPAIR.

spar webs is $4\frac{1}{2}$ mm., and that for the rear spars $\frac{1}{8}$ in., both plys being of the double thickness centre lamination type, with the grain set at 45° to the centre section datum.

B. Rib Repairs

Ribs in the centre section between spars are of two types, spruce warren girder ribs and box ribs with spruce flanges and ply webs. Aft of the rear spar, the ribs are of spruce warren girder type construction.

Negligible Damage and Minor Damage. Between the spars, damage to the spruce members is covered by that quoted in the Fuselage Repair, p. 626, A, paragraphs 1 and 2. For the ply webs, see pp. 627–628, B, paragraphs 1, 2 and 3. Aft of the spars, see pp. 628–629, C, paragraphs 1, 2 and 3, applies.

Major Damage. Between the spars, damage to the spruce members, greater than can be dealt with by the methods quoted above, must be dealt with by replacement of the member affected, splicing in new portion not being permissible.

EXTENSION PLANES

A. Spar Repairs

1. Flange Repairs

Negligible Damage. Damage consisting of a bruise not more than 0·1 in. deep by 1 in. diameter or which can be cleaned out to leave a smooth surface within the above limits, is negligible wherever it may occur, provided that no two such places occur within the same rib bay.

Minor Damage. Damage to the surface of the flange up to 0·5 in.

deep at the root, decreasing to 0·1 in. deep at the tip, and proportionately between, and extending to the full width of the flange, must be repaired by means of an insertion, as detailed under centre section spar flange repairs, p. 631, A1, Minor Damage, and illustrated in Fig. 6. A repair of this type may be of any length, anywhere on the spar except over the inner 20 in. of each spar, in the way of the walnut wedge blocks.

Major Damage. Damage greater than can be dealt with by the methods given in the minor damage section must be repaired by renewal of a portion of the spar flange, splicing it in a similar manner to that described for the centre section, but observing the following limits :—

(*a*) No splice may be made within 5 ft. of the root end.

(*b*) No two splices may occur within 2 ft. of one another.

2. Web Repairs

Negligible Damage. Damage in the form of a clean hole not more than 0·5 in. diameter or which can be cleaned out to leave such a hole, is negligible, provided it does not occur within 0·5 in. of the edge of the spar flanges or internal stiffeners and not more than one such hole in any one panel of ply.

Minor Damage. Damage of a similar nature to that described above, but extending up to 1·5 in. diameter in the central area of a panel or to within 0·5 in. of an internal member, must be repaired by patching. Clean out the damaged area to leave a smooth edged regular shaped hole and prepare a patch, of 2 mm. ply, $1\frac{1}{2}$ in. bigger all round than the hole. Chamfer the edge of this over the outer 0·5 in. down to the thickness of one lamination, glue and brad in position.

Major Damage. Damage greater than can be dealt with by the methods given above, must be repaired by replacing a portion of the web, as detailed for the centre section webs, p. 632, A2, Major Damage. The ply on all spars is $\frac{1}{8}$ in. thick over the inner two-thirds approximately of the spar, and $\frac{3}{32}$ in. thick beyond that, being double thickness centre lamination ply, set at 45 degrees to the wing datum.

B. Rib Repairs

The extension plane ribs are of spruce warren girder construction, with built-up " T " section flanges and flat spruce bracing. Repair is throughout as detailed for the Fin Rib Repairs, p. 628, C, Rib Repairs.

C. Diagonal Bracing

Diagonal bracing ribs of spruce with warren type bracing are fitted between the spars, anchored thereto with duralumin plate fittings and 3-ply gussets. No damage to this bracing is negligible and repair is by replacement of the damaged member.

D. Trailing Edge Repairs

The trailing edge is a streamline section dural tube. Repair is by

replacement of the damaged portion, using an internally sleeved joint at each end of the new section. A repair of this type is illustrated in Fig. 8. Cut out the damaged portion of tube to a minimum length of 4 in. Cut a new piece of tube to fit the gap, leaving 0·1 in. clearance at one end. Then take two sections of tube, each 4 in. long, cut approximately $\frac{1}{8}$ in. off the trailing edge and squeeze up to make an easy fit in the standard tube. Mark the centres of these sleeves with a centre punch or some other clear mark. Insert the sleeves, one into each end of the standing portions of the tube, fit the new portion of tube, and work the sleeves back across the gaps with a scriber or other sharp pointed instrument till the marked centres of the sleeves show in the gaps. Then secure with two $\frac{1}{8}$ in. diameter dural taper pins each end.

CONTROL SURFACES. (AILERONS, TAILPLANE, ELEVATORS AND RUDDER)

All the control surfaces of the Envoy are of similar construction, with spruce and ply box spars and warren braced spruce ribs.

A. Spar Repairs

Repairs to the spars are to be carried out in the manner described for the Fin Spar Repairs, p. 629, C.

B. Rib Repairs

Repairs to the ribs are to be carried out in the manner described for the Fin Rib Repairs, p. 628, C.

C. Trailing Edge Repairs

The trailing edge of these components is made from the same streamline section dural tube as is used for the extension planes and should be repaired in the same way, p. 635, D.

ENGINE MOUNTINGS

The welded steel tube engine mountings are made throughout of 17 S.W.G. tube to Specification T.45, with the exception of the engine ring itself, which is of 14 S.W.G.

Negligible Damage. No damage occurring in the middle third of any strut length is negligible. Outside the middle third of a strut, a smooth dent not greater than 0·05 in. deep by 0·5 in. diameter is negligible, provided there is not more than one such dent in any one strut leng' and that the tube itself is not bent at the same time to an extent greater than 1/600th of its length.

Major Damage. There is no minor damage allowable on the engine mountings. Any damage greater than that covered by the negligible damage section calls for the full repair, which is by replacement. Cut away the damaged tube to within 1 in. of the end, prepare a new length

of tube of the same size as the original to fit the gap and butt weld this into position. Where two tubes meet at an angle, the 1 in. dimension is to be taken from the junction of the two tubes. The ends of the tubes at the joint should be chamfered before welding to an angle of approximately 60 degrees, so as to form a "V" round the circumference which will be filled by the welding. If the ring itself is damaged, a new section may be inserted, with the ends butt welded, over any length or section of the ring.

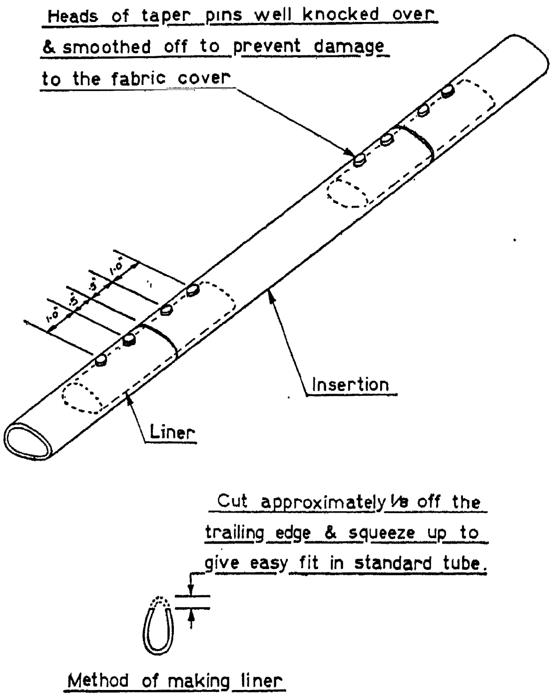


Fig. 8.—TRAILING EDGE REPAIR.

Engine Mounting Attachment Points. The construction of all four attachment points on the mounting is similar, a distance tube being welded in between the side plates and flattened end of the tube. In the event of wear or damage taking place to these holes, drill out the hole to $\frac{1}{2}$ in. diameter and insert a $\frac{1}{2}$ in. diameter by 14 S.W.G. steel tube right through. Countersink the face of the washer plates on each side and weld the distance tube in place. Clean off the faces and drill and ream the hole to $\frac{3}{8}$ in. diameter $\begin{smallmatrix}+\,0{\cdot}0025\\+\,0{\cdot}0005\end{smallmatrix}$. On the centre section the top fittings are of steel and may be opened out to $\frac{1}{2}$ in. diameter and bushed to restore them to their original $\frac{3}{8}$ in. diameter. The bottom fittings of dural are already provided with steel bushes, and these should be driven out and renewed.

UNDERCARRIAGE

Throughout this section there is no negligible damage and repair is by replacement only. Damage to any of the struts or axle, however slight, calls for replacement of the affected part.

Wear at Hinge Points

At all the hinge points in the retracting mechanism, the hinge pins are

locked against rotation in the female fitting, all the movement taking place in the male fitting. By this means, wear is restricted to the male portion, this has been made large enough in bearing area to give long life and is also large enough to allow opening out and bushing if wear does take place. Below are given detailed instructions for dealing with wear at the various undercarriage joints. Care should be taken when opening out holes to see that the new hole is kept concentric with the original hole.

Oleo Leg Top and Bottom Joints

Ball joints are provided at the top and bottom of the oleo legs, these are adjustable for wear. The housings carrying the balls are screwed into the ends of the cylinder and piston respectively and are locked by studs at the top and a taper pin at the bottom. Wear of up to 0·02 in. on the diameter of the ball is permissible before adjustment is necessary. To adjust, remove the studs or taper pins securing the ball housing to the oleo leg, unscrew the housing and remove from the leg. Inside the housing will be seen the adjusting screw for the bearing pad. Remove the taper pin locking the screw and remove the set screw locking the pad against rotation. Adjust the screw until there is no play in the ball, which should still be free to rotate, re-drill the screw and lock with a taper pin. Before making any adjustment to the screw, mark the position of the pin hole in the screw, check that this does not come within 30 degrees of the position of the new pin hole before drilling the latter. If necessary, to avoid this, a completely fresh hole may be drilled in housing and screw, at 90 degrees to the original hole in the housing. Replace the set screw locating the pad, reassemble the housing to the leg, locking by the studs or taper pin as appropriate.

Axle, Top Joint

This is a double joint, the axle pin being free to rotate to allow the axle to swing during retraction. End play of up to 0·01 in. is permissible in the spindle before any adjustment is necessary, such adjustment being made by shims in the form of washers on the spindle. Before dismantling the socket from the bearing, measure with feelers the amount of play and prepare a washer of the thickness necessary, noting also at which end most of the wear appears to have taken place. Remove the sleeve securing the axle pin to the socket in the centre section, insert the shim at the appropriate end and replace the sleeve. Radially, wear of up to 0·01 in. on the diameter is permissible before action is necessary. When wear has reached this stage, open out the hole in the bearing to 1·39 in., 0·01 in. increase on the original diameter and fit a new axle pin and securing sleeve having correspondingly increased pin diameter. A further 0·01 in. wear is permissible, when the bearing should be opened out to 1·40 in. diameter and a new pin fitted to suit. A still further

0·01 in. wear is permitted, after which the bearing fitting must be renewed.

In connection with the opening out of the bearing, the following limits must be observed :—

1. The bearing must not be opened out beyond 1·40 in. diameter.

2. The wall thickness of the bearing must not be reduced to less than 0·07 in. at the outer flanged end or 0·055 in. at the inner end, and proportionately between. At the $\frac{9}{16}$ in. hole in the axle pin for the joint to the axle itself, play of up to 0·01 in. is permissible. If wear is such as to be more than 0·01 in., open out the hole in the axle pin to $\frac{11}{16}$ in. diameter and fit a bush to restore the fitting to the original $\frac{9}{16}$ in. diameter. Re-make the joint with a new standard joint pin.

It is not anticipated that wear will take place in the fork fitting on the axle at this point, but should play develop, due to the hammering of the fork against the pin in service, such play should not be allowed to exceed 0·005 in., after which the hole should be opened out to $\frac{5}{8}$ in. diameter and bushes fitted to both sides to restore the hole to $\frac{9}{16}$ in. diameter. After once bushing the joint, any subsequent wear can be dealt with by renewing the bushes.

Radius Rod Joints and Ram Attachment Joints

The method of adjustment for wear at all these joints is the same and consists of restoring to the original $\frac{1}{2}$ in. diameter by bushing. Wear of up to 0·01 in. is permissible at all joints before action is necessary. In all cases, rotation of the pin is confined to the male portion of the joint, and when wear exceeds 0·01 in. this fitting should be opened out to $\frac{5}{8}$ in. diameter and bushed to restore it to the original $\frac{1}{2}$ in. diameter. Re-make the joint with the appropriate standard new joint pin. Should wear develop in the female portion of the joint of more than 0·005 in., the hole may be reamed to $\frac{9}{16}$ in. and bushed to restore it to $\frac{1}{2}$ in. diameter.

After once bushing, any further wear at the joints beyond the amounts stated, can be dealt with by renewing the bushes.

FLAPS

Repair in this section is limited to the metal skin. Damage to operating torque tube, rods and levers calls for replacement of the affected part.

Negligible Damage

A dent in the skin, however deep, is negligible, provided that it does not affect any stiffener or the trailing edge and does not penetrate the skin or prevent the flap from closing.

Minor Damage

Damage in the form of a clean hole up to 3 × 3 in. or which can be cleaned out to leave such a hole, is to be repaired by patching. Clean

out the damaged area to leave a regular shaped hole and prepare a patch 0·5 in. bigger than the hole all round. This patch should be of the same material as the flap skin, which is 24 S.W.G. " Alclad " to Specification D.T.D. 111. If " Alclad " is not available, then 24 S.W.G. duralumin or 22 S.W.G. aluminium may be used. Secure this patch in position on the flap with $\frac{3}{32}$ in. diameter light alloy rivets, pitched at between 1 in. and 0·75 in. on a line 0·25 in. in from the edge of the patch.

Major Damage

Damage greater than can be repaired by the means given in the Minor Damage section, must be repaired by renewing completely a section of flap skin. The new section of skin, which must be made from 24 S.W.G. " Alclad," is joggled at the ends to form an overlapping joint with the remainder of the skin, the end joints being made on a stiffener.

THE "GIPSY II & III" AERO ENGINES

By A. J. Brant, *Service Manager, de Havilland Aircraft Ltd.*

THE 120 h.p. "Gipsy II" gives the opportunity of introducing a "Vertical" 4-cylinder in-line aero engine to this series of articles and with it has been coupled the 120 h.p. "Gipsy III" "Inverted" engine as many of the main components are identical and it can be conveniently covered with advantage to the reader.

The "Gipsy II and III" engines belong to the range of the de Havilland productions and many hundreds of these types are in world-wide use.

The following is a list of the leading particulars :—

Type (Gipsy II) 4-cylinder, vertical, air-cooled, in-line, direct drive, wet sump.

Type (Gipsy III) 4-cylinder, inverted, air-cooled, in-line, direct drive, dry sump.

Rotation. Left-hand tractors.

Bore. 114 mm.

Stroke. 140 mm.

Capacity. 5,713 c.c.

Maximum b.h.p. at normal r.p.m. 108–110 at 2,000 r.p.m.

Maximum b.h.p. at maximum r.p.m. 120 h.p. at 2,300 r.p.m.

Compression ratio. 5·2 to 1.

Weight complete with airscrew boss (Gipsy II). 298 lbs. (approx.).

Weight complete with airscrew boss (Gipsy III). 290 lbs. (approx.).

Fuel consumption. 0·57 pint per b.h.p. per hour.

Fuel consumption per hour 9/10 throttle at 2,000 r.p.m. 6·75 gallons (approx.).

Fuel consumption per hour at full throttle at 2,300 r.p.m. 9 gallons (approx.).

Oil consumption. 1¼ pints per hour (approx.).

Oil pressure. 40 to 45 lbs. per square inch (35 lbs. per square inch minimum).

Oil temperature. Inlet 50° C. to 70° C. (maximum 85° C.).

Oil in circulation. 8 pints (minimum permissible).

Carburetter (Gipsy II). Claudel Hobson A.V. 48D.

Carburetter (Gipsy III). Claudel Hobson A.H. 45D (early engines).

Carburetter (Gipsy III). Claudel Hobson A.I. 48 (later engines).

Magnetos. One B.T.H. A.G. 4-4 anti-clockwise.

Magnetos. One B.T.H. A.G. 4-4 clockwise, fitted with impulse starter unit.

Fig. 1.—DAILY MAINTENANCE ROUTINE (1).
External inspection including observation for chafing, looseness or displacement of parts.

Sparking plugs. K.L.G. 294, 633, V. 12 and Lodge A.55.

Fuel pump when required. Early engines A.C. Sphinx, but later D.H.A.C.

Fuel. Any good grade automobile fuel with minimum octane value 70, obtained by the C.F.R. motor method (modified to 260° F. mixture temperature) without the use of tetra-ethyl-lead.

Oil. Oil to specification D.T.D. 109 and a range of proprietary brands are also approved by the manufacturers.

General Description

Cylinder Heads

The cylinder head is separate from the cylinder and is held to this part by four high tensile steel bolts screwed into the crankcase. The joint between the head and the cylinder is made by a copper and asbestos washer which fits in a recess in the cylinder head. Provision is made for one inlet and one exhaust valve in each cylinder head. Two sparking plugs are fitted ; one on each side of the cylinder head. The inlet and exhaust ports are on one side of the engine. The cylinder heads on the early engines were an aluminium alloy casting with shrunk in aluminium bronze valve seatings, but later engines have the cylinder heads cast in aluminium bronze and the valve seatings are formed directly in the material of the head.

Cylinders

The cylinders are steel forgings machined all over.

Pistons

The pistons are of the slipper type cast in aluminium. Three rings are fitted, the rings nearest the gudgeon pin being of the scraper type.

Connecting Rods

On early engines the connecting rods were forgings in "Y" alloy, but later this was changed to specification D.T.D. 130. Leak holes are provided in the cap of the rod and bearing to ensure cylinder and piston lubrication.

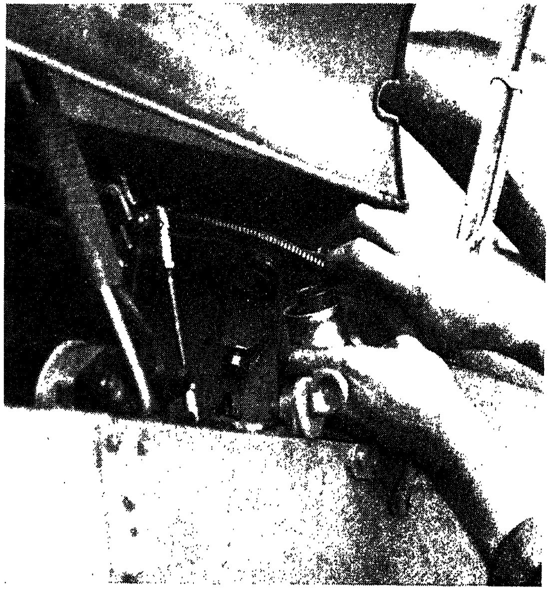


Fig. 2.—DAILY MAINTENANCE ROUTINE (2).
Clean the fuel filter. The filter is on the bulkhead on Gipsy II installation.

Crankshaft

The crankshaft is a one-piece forging of special steel.

Crankcase

This is a deep section casting in aluminium alloy, the front wall and a tapered section between them carrying the housing for the long front main bearing. The rear bearing housing is carried by the rear wall of the crankcase.

Each of the intermediate bearings are in housings, supported by stiff cross webs. All main bearings are held in separate caps, thus facilitating assembly, overhaul and inspection, as none of the bearings need be disturbed when the sump is removed. Facings for engine bearer feet, oil filler and breathers are provided for on this member.

Camshaft

The camshaft is of special steel and rotates in five plain bearings, which, with the tappets, are lubricated by oil mist.

Sump and Oil Filter (Gipsy II only)

This is of the wet type and can contain 20 pints of oil. A gauze screen is attached by cheese-headed screws to a ledge provided in the

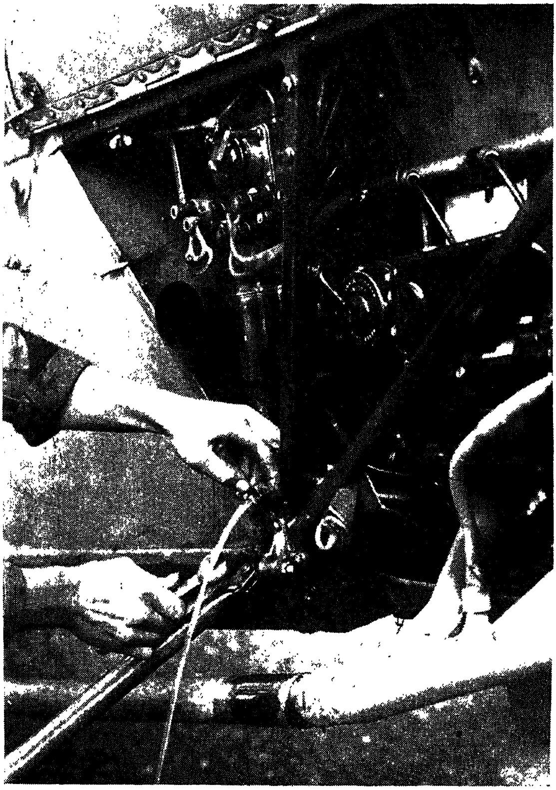


Fig. 3.—DAILY MAINTENANCE ROUTINE (3).

Disconnect pipe at carburetter and allow fuel to flow full bore and connect while flowing to avoid air locks.

sump, and filters the oil which is poured into the engine through the filler provided on the crankcase. A special tray can be fitted underneath this gauze screen if the engine should be required to run in an inverted position. In this case the tray holds the oil in the sump, and prevents the piston being flooded. The main oil pressure filter is enclosed in an aluminium alloy casting, and this is bolted to a facing on underside of sump. This filter is accessible by undoing one large hexagon cap. Fins are provided on the underside of the sump and assist in keeping oil temperatures low when the sump is well ventilated.

Valves and Valve Operating Gear

The valves are made of steel. The inlet valve head is of tulip form and is slightly larger in diameter than the exhaust, which has a mushroom head. Both are operated by steel rockers through tubular duralumin push rods which have hardened steel ball and socket joints at both ends. The ball on the rocker end, which is adjustable and locked by a hexagon nut, provides for tappet adjustment. The rockers oscillate on a hardened steel spindle which is clamped in a stamped steel bracket bolted to a lug provided on the cylinder head. Floating phosphor bronze bushes fitted between pin and rocker minimise wear at this point.

Fitted to the valve stems are hardened steel thimbles which, being free to turn, reduce wear to a minimum and prevent the formation of

grooves where the rocker pad strikes. The rocker pads can be replaced when worn, as they are riveted in the rockers. This avoids local hardening of the rockers, with the attendant risk of fracture of this part during running.

Fig. 4.—DAILY MAINTENANCE ROUTINE (4).
Check compressions.

Timing Gears

These are housed in a separate cover attached to the rear end of the engine. This cover is held on a facing provided on the crankcase and sump by studs and nuts. A spur gear fitted in the rear end of crankshaft drives the camshaft through the medium of an idler gear. The camshaft gear is fitted with a vernier adjustment permitting close valve timing. Bolted to an extension of the idler gear is a skew gear, meshing with a similar gear mounted on a short shaft above. This shaft has a Simms flexible coupling fitted to each end, and through these couplings the magnetos are driven. The magnetos are bolted on sturdy brackets which are part of the rear cover.

The gear oil pump is bolted to a facing on the lower part of this cover, and carries a spur gear which meshes with the crankshaft gear. Between the idler gear and the magneto driving gear is a small skew gear which, meshing with a similar gear, drives a single or double tachometer drive as required. One of the magnetos is fitted with an impulse starter which causes the magneto to deliver a very strong spark at low revolutions.

This ensures ignition for easy starting. The contact breakers and distributors are arranged to point outwards, thus being accessible for adjustment and inspection.

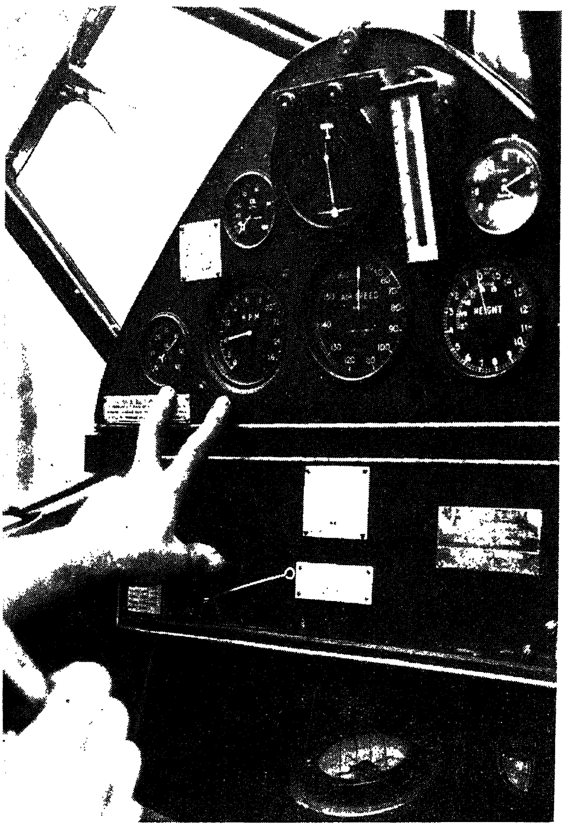


Fig. 5.—DAILY MAINTENANCE ROUTINE (5).

Run engine and watch revolution counter and oil-pressure gauge.

Induction System

A square section welded steel manifold is used both on the Gipsy II and III. The manifold is fitted with an exhaust heated muff on the portion which leads from the manifold proper to the carburetter. All Gipsy II engines are fitted with the Claudel Hobson type A.V. 48D carburetters. The early Gipsy III's have the Claudel Hobson A.H. 45D and later A.I. 48.

Lubrication (Gipsy II)

Oil is drawn from the sump by the gear pump provided on the timing gear cover. A spring-loaded piston valve working in a bronze liner in the rear pump cover acts as a release valve, and pressure is adjusted by shims between the end of the spring and the piston. The oil is carried by pipes to the filter casing attached to the sump and from there to the main oil gallery, which is attached to connections on the port side of the crankcase. Holes provided in the crankcase leading from these connections lead the oil at 40 to 45 lbs. per square inch to the five main bearings. From the main bearings oil is forced into the hollow crank pins, which supply the big end bearings. Holes are provided on the big end bearing caps and bearings, from which oil is thrown on to the cylinder walls. Piston lubrication is thus effectively maintained.

Camshaft bearings, tappets and cams also benefit from the oil thus thrown from the connecting rods. The surplus passes through a gauze filter tray on its return to the sump. The supply is replenished through

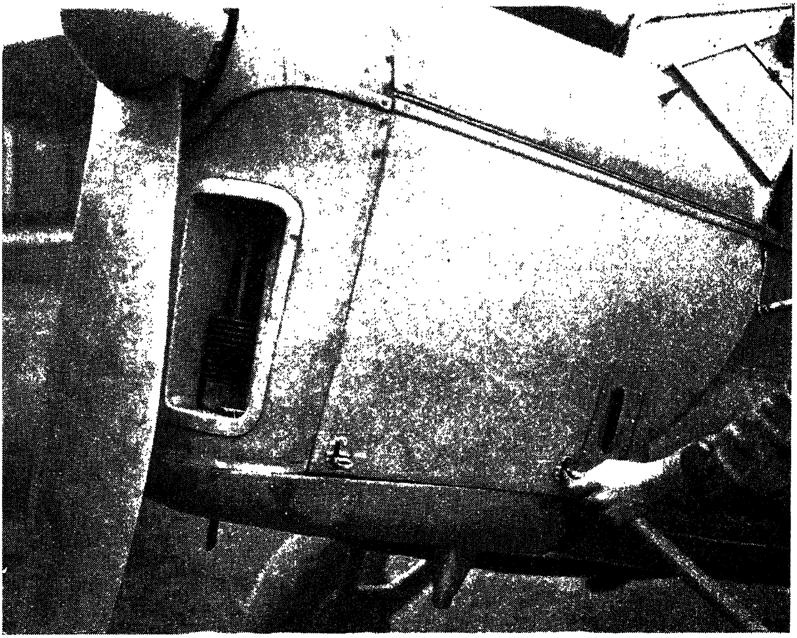
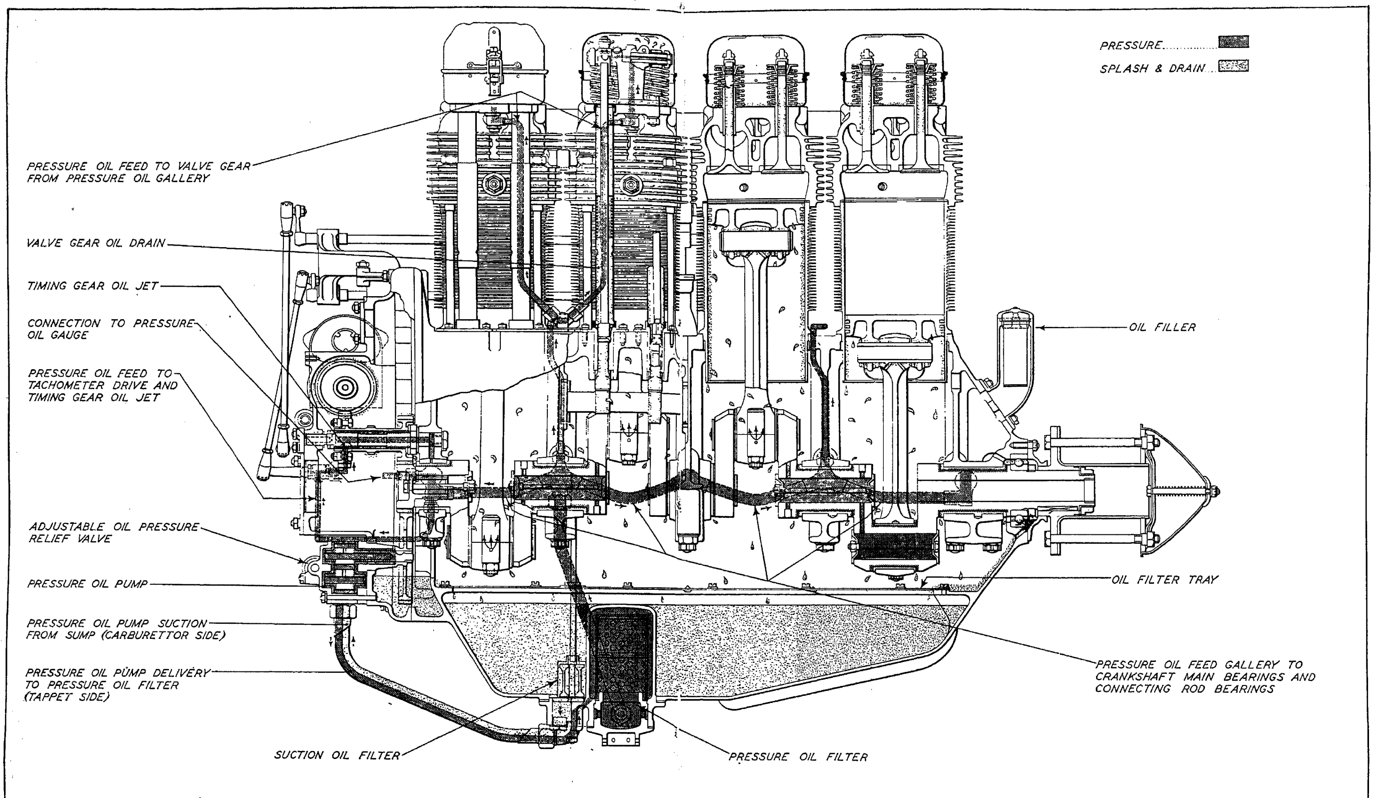


Fig. 6.—DAILY MAINTENANCE ROUTINE (6).
See that cowling is properly fastened.

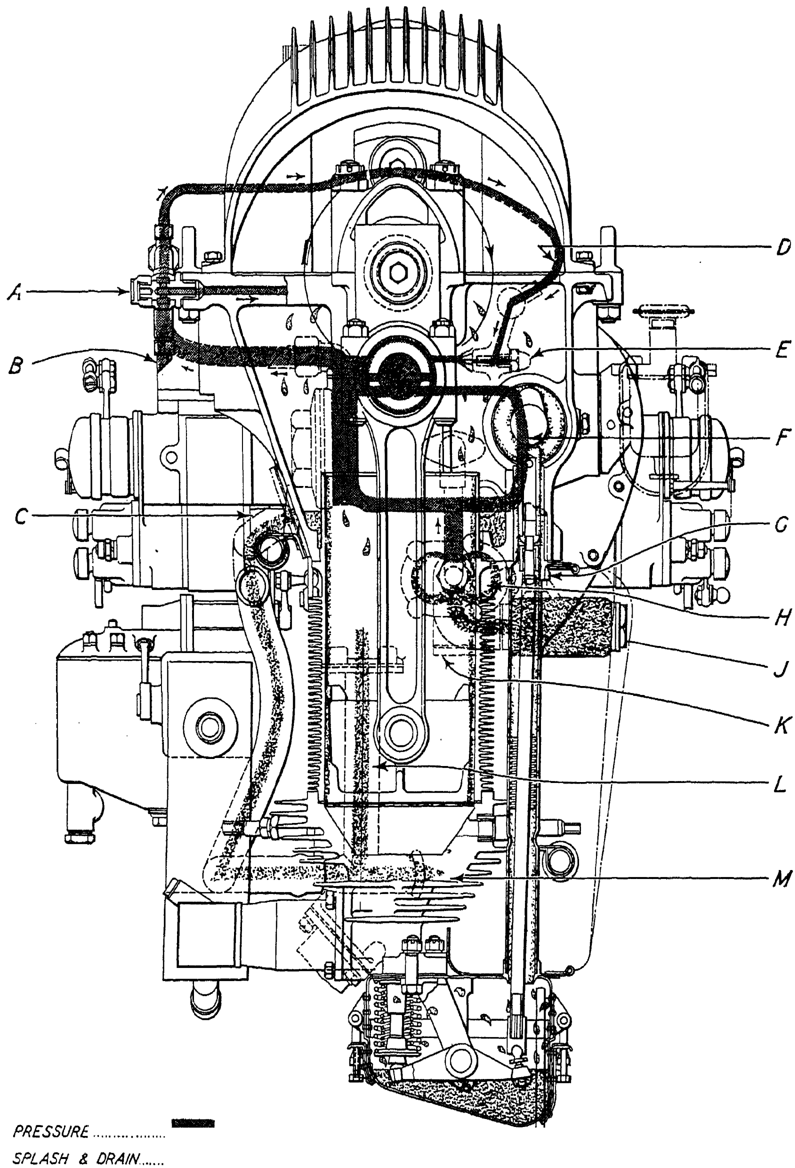
a filler cap in the nose of the crankcase, while the quantity of oil in the sump can readily be ascertained by means of the " dipper " rod provided. A drilling in the crankcase leads oil from the rear main bearing to a recess formed in the idler gear spindle. This is suitably drilled to release the oil midway between the two bronze bearings fitted to each end of the idler gear.

From two connections on the oil gallery, vertical feeds are taken which pass between the cylinders and are connected to a three-way fitting attached to the crankcase on the starboard side. Two pipes are run from each of these connections to the underside of the valve gear casing of each cylinder.

The oil is then passed through a drilling provided in each rocker bracket and thence through the hollow rocker spindle to the rocker bearings. A metering plug is provided in each valve rocker bracket to govern the amount of oil passed. The oil, after being passed from the rocker bearings, exudes from a hole, and thence along a groove provided on the top of the rocker. This groove leads the oil to each end of the rocker and provides lubrication for the valve thimble and stem and for the tappet rod ball joint. The oil which is fed to the valve gear is caught in a pressed steel casing, which is clamped between the rocker bracket and cylinder head.



LUBRICATION DIAGRAM OF DE HAVILLAND GIPSY II AERO ENGINE.



LUBRICATION DIAGRAM OF DE HAVILLAND GIPSY III AERO

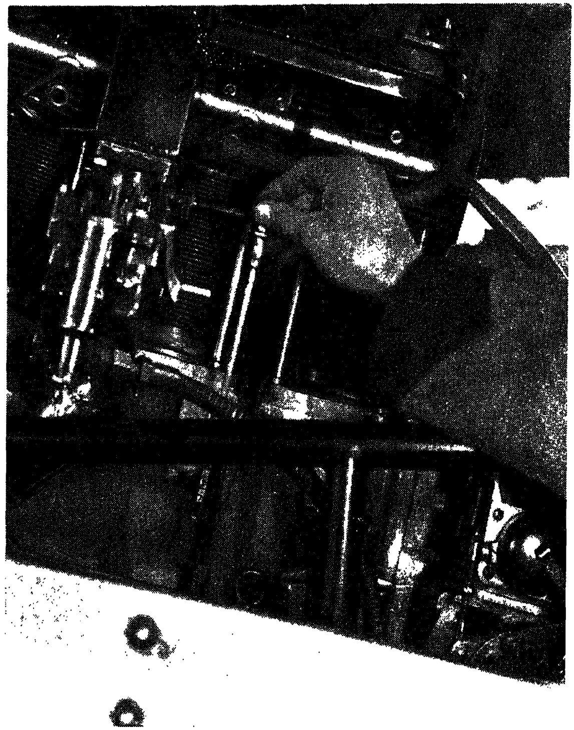


Fig. 7.—Daily maintenance routine (7).
Check oil level (showing dip stick on Gipsy II group).

Telescopic aluminium tubes which fit in recesses provided in the tappet guides and under the valve casing carry the oil back to the crankcase *viâ* grooves formed in the tappet guides. A pressed steel cover fitting in a recess formed in the top edge of the valve casing catches any oil thrown off the valve gear and returns it to the valve casing. A shackle type of fixing, attached to each side of the cover, holds these in place. A dermatine ring is fitted between casing and cover to seal the joint.

At the rear end of the oil gallery connections are provided for two pipes, one of which supplies oil to the tachometer drive shaft bushes and magneto gear jet, and the other for connecting up to the oil pressure gauge.

Lubrication (Gipsy III)

Oil is drawn from a separate tank by a gear type pump situated on the timing cover and driven by a gear which meshes with the camshaft wheel. The oil pressure is regulated to 40/45 lbs. per square inch by an adjustable relief valve in the cover of the pump casing.

From the pump, the oil under pressure flows through a "Tecalemit" felt filter which ensures the removal of even the finest particles of foreign matter before the oil passes into the engine. This filter is positioned on the timing gear cover and is easily removed either for cleaning or for renewal of the element. On earlier engines the filter consisted of a fine gauze. From the filter the main supply is taken to an external gallery along the side of the crankcase and connected by drillings to the five main bearings. Thence the oil passes into the crankshaft and so through

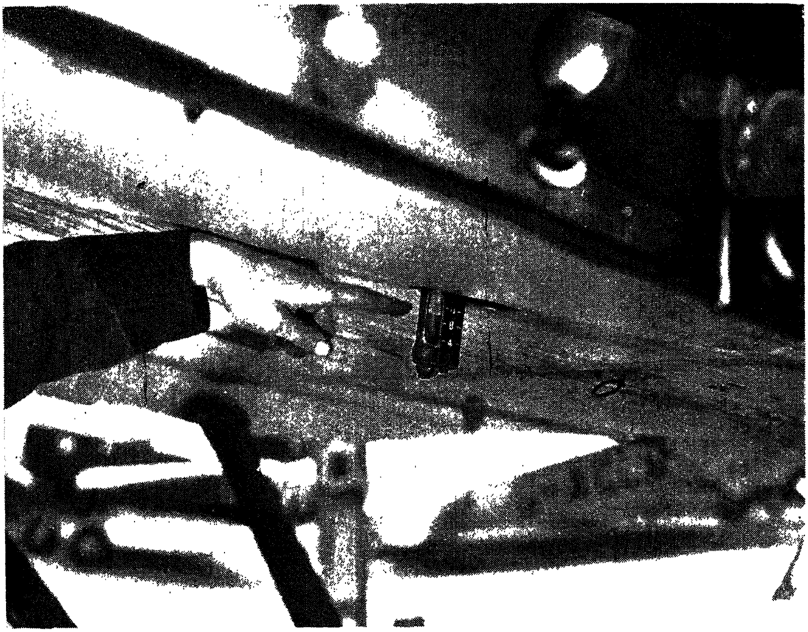


Fig. 8.—DAILY MAINTENANCE ROUTINE (8).
Check fuel level (showing gauge on Puss Moth Gipsy III).

the hollow journals and crank pins to the big ends. Holes are drilled in the big-end bearings and connecting rod caps, from which oil is thrown on to the cylinder walls and pistons.

This arrangement is particularly useful at starting, as proper lubrication of the pistons is established during the first revolutions of the engine. Moreover, the supply of lubricant to the cylinder walls is maintained irrespective of wear and clearances in the main bearings. The spray thus created inside the crankcase serves to lubricate the camshaft bearings, cams and tappets, and, as a good deal of it ultimately comes into contact with the walls of the top cover, a useful cooling effect is obtained.

Two connections are provided at the rear end of the oil gallery, one supplying oil to the timing gears, the other for connecting up to an oil-pressure gauge. After passing through the engine, the oil collects in the space formed by the extension of the cylinders into the crankcase, whence it is returned by external pipes to the tank. Here the oil is allowed to settle and cool before being pumped back into the engine.

Oil which leaks by the tappet guides is led by the tappet rod casings to the valve casing cover. A dermatine ring is fitted between the casing and cover to seal the joint. Attached to these covers is a vent pipe to release oil gas, fumes, etc. The vent pipe carries a ring to indicate the

oil filling level when replenishing during maintenance routine. The movement of the rockers causes oil to be splashed over all the moving parts of the valve gear, and so provides for adequate lubrication.

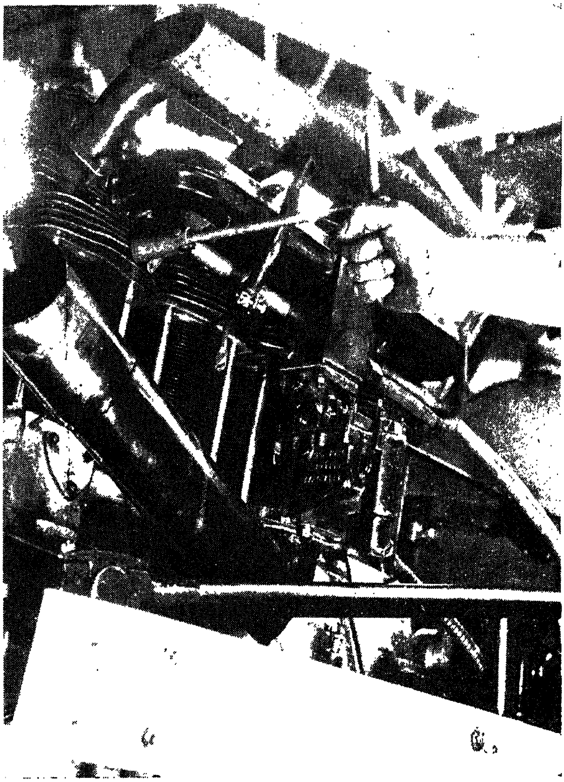


Fig. 9.—25-HOUR ROUTINE (1).
Remove sparking plugs (Gipsy II).

Fuel System

A large number of Gipsy II and III engines are operating in aeroplanes with a normal gravity feed fuel system, but fuel pumps can be provided for when required. On the very earliest engines only one face was provided on the crankcase for the cam operated diaphragm type A.C. Sphinx fuel pump, but later provision has been made for the Dual D.H.A.C. pumps. The D.H.A.C. fuel pumps are also standard in the Gipsy Major engine when pumps are required, and these will be described in detail later.

Maintenance and Overhaul Routine

The Gipsy II and III engines are particularly easy to maintain and the daily work will amount only to an external inspection to ensure no looseness, chafing or displacement of parts, checking compressions and running the engine to determine that satisfactory even running has been maintained.

After each twenty-five hours' flying the following routine should also be carried out :—

1. Dismantle, clean, reset points and test sparking plugs.
2. Clean suction and pressure oil filters.

Fig. 10.—25-HOUR ROUTINE (2).
Dismantle and reassemble (using special box spanners).

3. Clean fuel filter.

4. Check magneto contact breaker gaps and reset if necessary.

5. Check valve clearances and reset if necessary.

6. Before replacing valve gear covers, add engine oil to bring up to level of ring on vent pipe.

7. Drain oil system and fill with fresh oil.

8. Remove and check carburetter jets and flush float chamber.

9. Check tightness of airscrew bolts. This should be done more frequently if airscrew is new or if the aeroplane is operating in a hot climate.

After 50 Hours' Flying

On engines fitted with the "Tecalemit" oil filter a new element must be fitted.

After 150 Hours' Flying

Cylinder overhaul and decarbonising must be carried out.

Instructions for Carrying Out Cylinder Overhaul

This overhaul can be carried out with the engine in position in the airframe and the sequence of operations as given below should be followed.

1. Remove split pin, nut and washer which holds airscrew spinner cap. Remove spinner cap, spring and large lock plate. Nuts on airscrew bolts can then be removed, using a box spanner and tommy bar. Remove spinner retainer, front plate and airscrew.

2. Remove cowling.

3. Remove carburetter heater pipe. Use correct spanner for union nuts.

4. Remove small nuts which hold exhaust manifold to cylinder head flanges, using the universal spanner. Manifold can then be lifted off studs and slid out of sleeve in exhaust pipe.

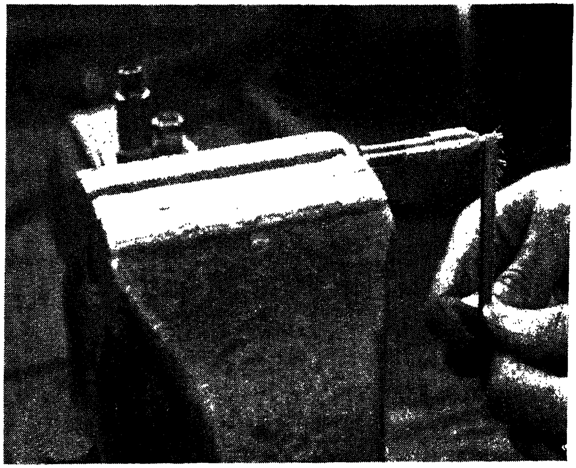


Fig. 11.—25-HOUR ROUTINE (3).
Clean (no abrasive method must be used on Mica insulation).

5. Unscrew fuel pipe union on carburetter.

6. Take out split pins in locating collars on torsion shaft of engine controls and slide shafts to the rear out of engagement with the carburetter.

7. Loosen clips which hold drain pipe to air intake pipe and dis-

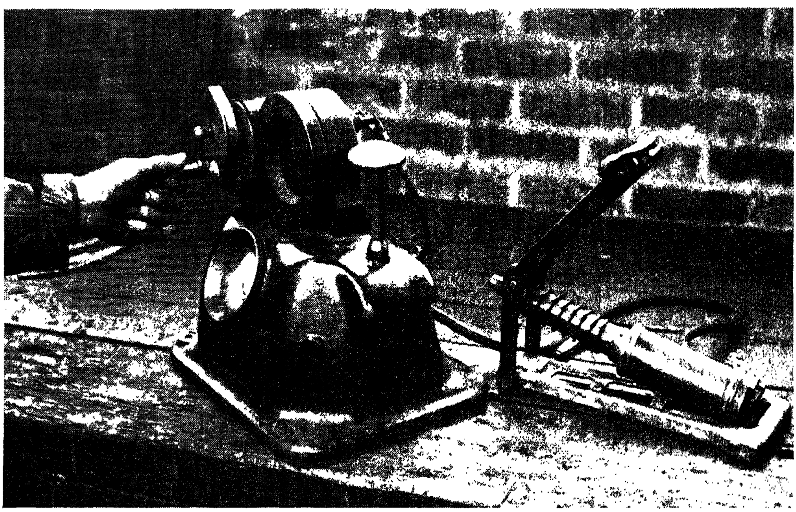


Fig. 12.—25-HOUR ROUTINE (4).
Pressure test.

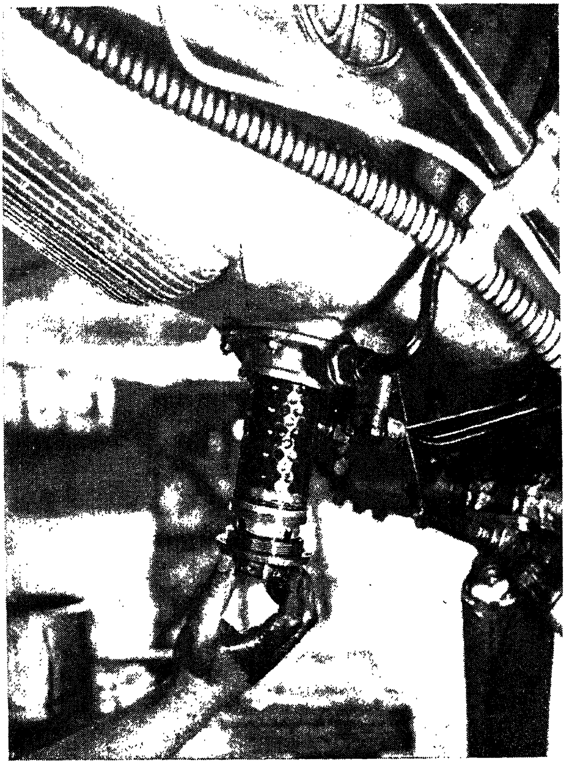


Fig. 13.—CLEAN PRESSURE FILTER ON GIPSY II.

connect pipe. Remove air intake by undoing bolts which hold this to carburetter flange. If an airscoop is fitted it may be necessary to remove this to get air intake clear.

8. Remove carburetter from induction pipe by undoing the four nuts which hold carburetter to induction flange.

9. Remove small nuts which hold induction manifold to cylinder head flanges, using the universal spanner. Manifold can then be lifted off studs.

10. Remove high tension leads from sparking plugs and unscrew sparking plugs from cylinders, using the box spanner and tommy bar.

11. Remove small bolts which hold port side high tension wire tubes and, leaving high tension wires still connected to magneto, place high tension wire tube and wires at rear of engine, so that they are out of the way of any further work to be carried out.

12. Unscrew small screws holding valve gear covers in place and swing stirrups clear. Remove valve cover and lift out dermatine ring from recess in each valve casing.

13. Depress valve collar slightly, which will depress valve and allow thimble to be lifted off. Remove all thimbles in this way.

14. Slacken off locking nuts on ball ends of rockers and then screw ball ends up into rockers as far as possible.

15. Push rocker and valve hard down ; tappet rod can then be withdrawn by moving it slightly to one side. Remove all tappet rods in this way.

16. Push top part of tappet casing tube down into lower part until clear of top cup. The tube can then be swung clear of top cup and lifted

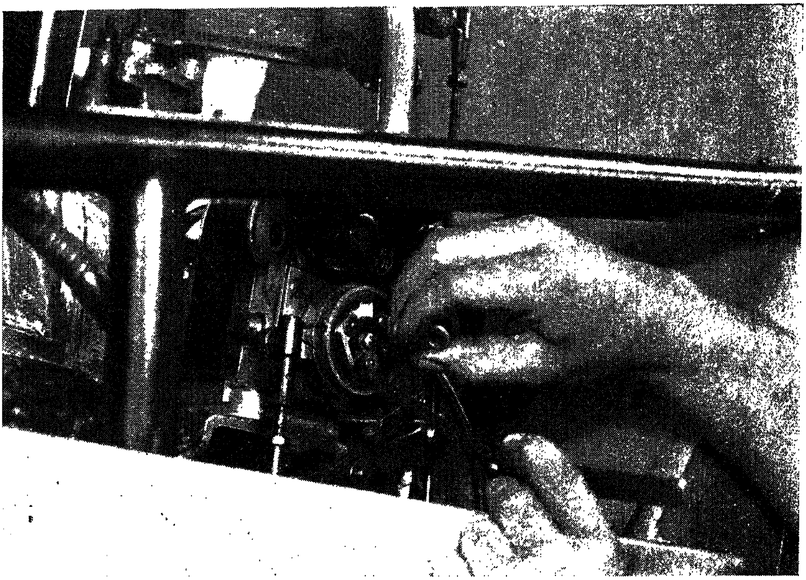


Fig. 14.—ADJUST CONTACT BREAKER (USING MAGNETO SPANNER).

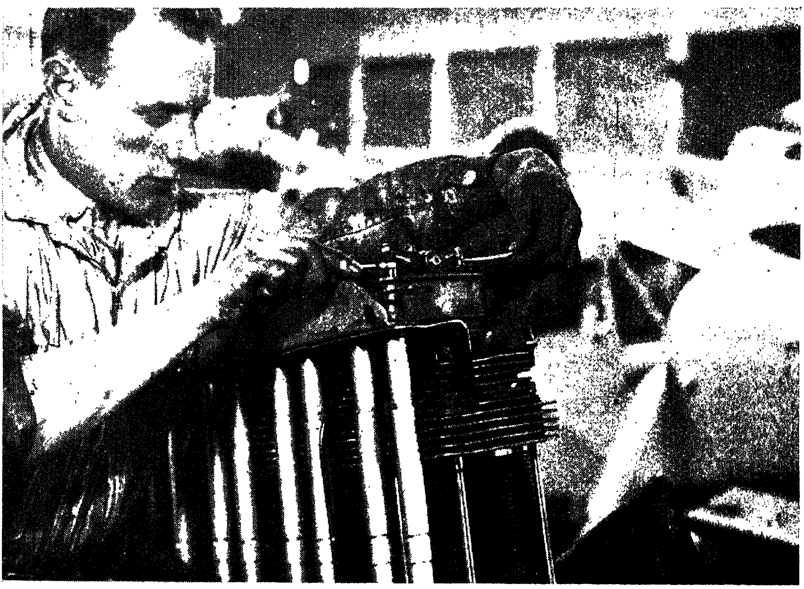


Fig. 15.—ADJUST VALVE CLEARANCE ("GIPSY II").

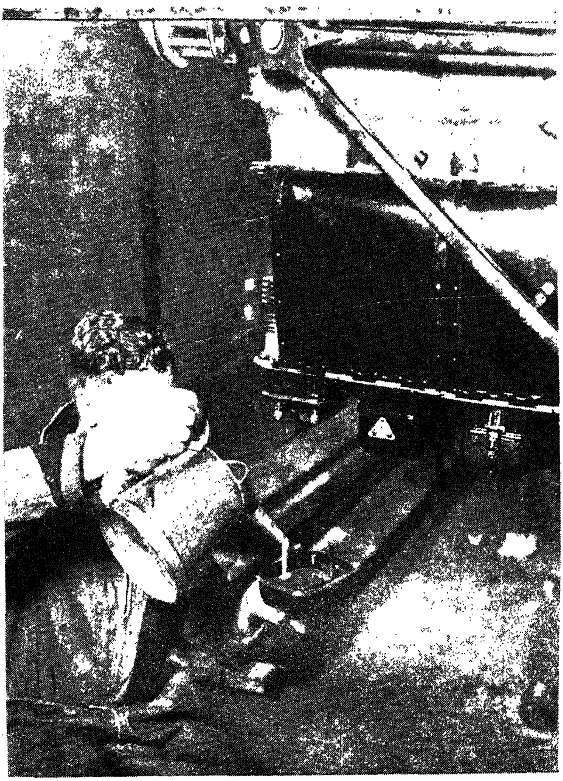


Fig. 16.—TOP UP LEVEL OF OIL IN VALVE COVERS (GIPSY III").

out of lower cup. Remove all tappet casing tubes in this way.

17. Remove small bolts which hold starboard side high tension wire tube, and follow out same instruction as given in item 11.

18. Loosen all cylinder head nuts. Ease cylinder heads up as these nuts are being unscrewed, and remove all nuts, washers and bridge plates. Should any of the cylinders show signs of sticking to cylinder heads, remove cylinder and head together, taking care to steady piston as cylinder is completely removed.

19. In the case of the Gipsy II disconnect oil feed pipes leading to valve casings. To make sure that metering plugs do not fall out replace small plug under rocker bracket after removing pipe.

20. With piston at end of stroke, carefully withdraw cylinders from crankcase. When cylinder is clear remove cylinder completely, steadying piston.

21. Remove circlip from one end of each gudgeon pin, using the circlip expander and screwdriver. Insert expander in slot in end of gudgeon pin and press handles together as far as possible, which will force circlip out of groove. Insert screwdriver between circlip and washer and a twist of the screwdriver will force circlip off end of gudgeon pin. After removal of washers, gudgeon pin can be pushed out and pistons lifted off. If gudgeon pin is too tight to be pushed out by hand, it should be extracted by using the gudgeon pin extractor.

22. Cover up holes in crankcase with rag or paper.

23. To dismantle cylinder heads. Push collars on valve rocker

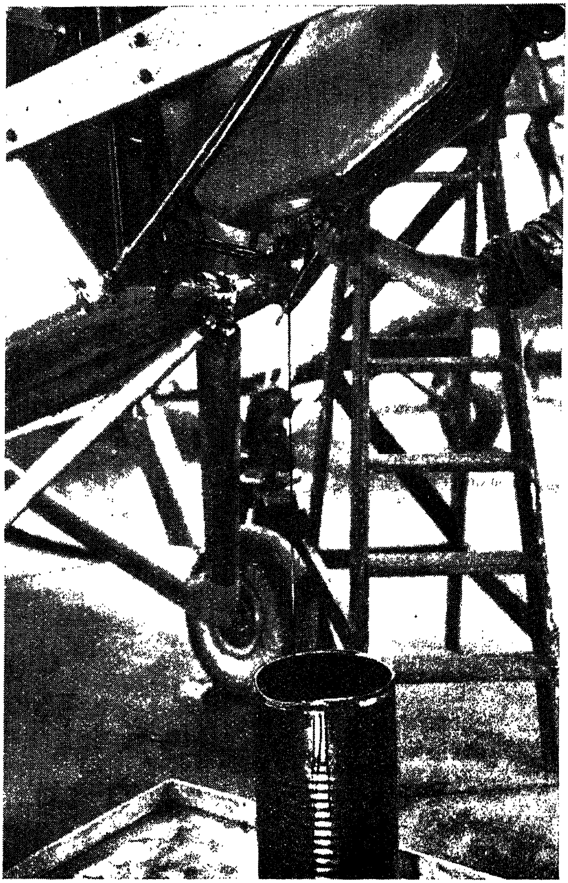


Fig. 17.—DRAIN OIL FROM SYSTEM ("GIPSY II" SUMP).

spindle as far as possible inwards, which will allow the small retaining pin in the end of rocker spindle to be withdrawn. After removal of pins, slide the retaining collars, springs, washers and rockers off rocker spindle. Place cylinder head over a small block of wood, sufficiently thick to hold valves up in place. Depress valve collar, using the valve spring compressor. Collets can then be removed from valve stems. Remove compressor and withdraw springs and collets. After lifting cylinder head off block, valves can be withdrawn.

24. To remove metering pin from under valve rocker bracket (on Gipsy II engine) proceed as follows: Close up all holes on one side of rocker spindle. Join up an oil squirt to the other side of rocker spindle with length of hose. After removal of plug below metering pin the metering pin can be blown out.

25. To remove piston rings from pistons. Insert three narrow strips of thin steel under piston ring and space out equidistantly. Piston ring can then be slid up strips. Commence with top ring and slide all rings upwards, that is towards crown of piston.

26. To separate cylinder head and cylinder. Fix a wooden peg vertically on bench. This peg should be an easy fit in bore of cylinder. Slide cylinder down on peg, which should be long enough to reach inside of head with cylinder clear of bench. If cylinder is brought down smartly, the peg striking inside of head will generally break head loose from

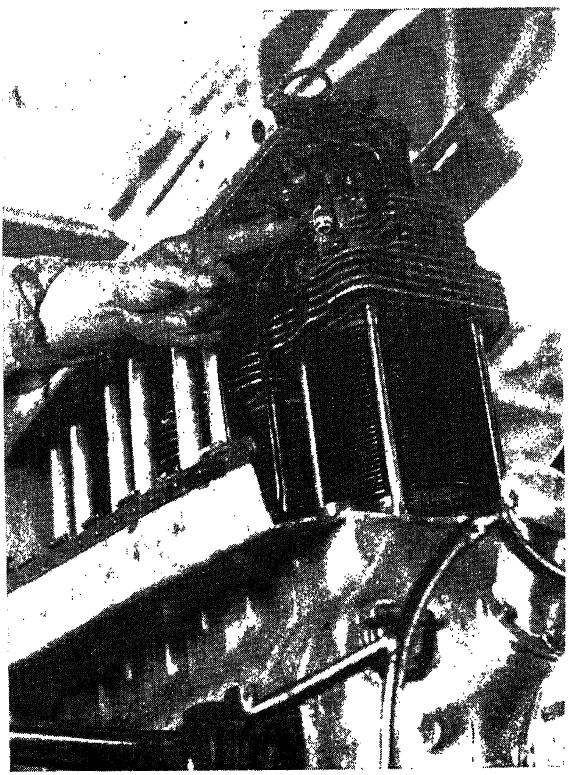


Fig. 18.—WHEN REMOVING OIL FEED PIPES TO VALVE COVERS MAKE SURE METERING PLUGS ARE NOT DAMAGED ("GIPSY II"). (SEE ALSO FIG. 19).

cylinder. If head cannot be moved by this means, heat up head in oil and try on peg again while hot.

Inspection

After cleaning and decarbonising all parts, the following points should be noted during an inspection of these parts.

Cylinder Heads (Aluminium Type)

Examine valve seatings for pocketing, pitting or any signs of looseness in cylinder head. In the event of a valve seating being loose, cylinder head should be returned to makers for re-seating. If pitting or pocketing is very pronounced a seating cutter should be used to true up seats before valves are ground in. If the seating on the valve itself is pitted or stepped, this should be ground to the correct angle before grinding with the cylinder head. Any signs of picking up or roughness on valve stems should be smoothed off and polished with superfine emery cloth. If valve guides or stems are worn beyond limits, new parts should be fitted. To remove valve guides, use special extractor. If valve guide is removed for any reason, the hallite washer between guide and valve gear casing should be renewed.

To avoid damaging the ends of the valve guides on replacement the soft drift provided should be used.

Bolts holding valve rocker bracket should be checked for tightness and tightened up and repinned if at all slack. Should valve rocker bracket be removed from cylinder head, the following points should be noted before replacement.

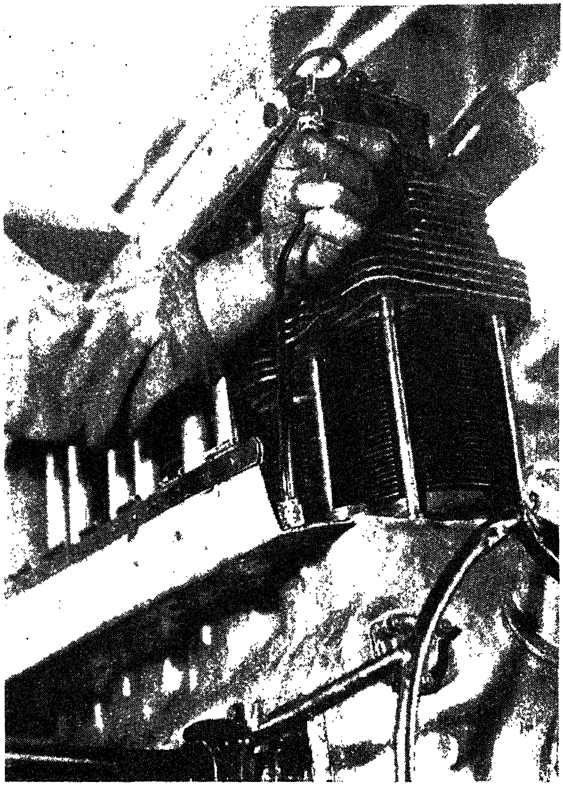


Fig. 19.—On later engines the metering plug is attached to adapter but on early engines it was a separate part.

All joint faces should be thoroughly cleaned and a new joint made between head of cylinder and valve gear casing and between casing and valve rocker bracket. L'Hermetical or similar jointing material should be used for these joints.

Check fits of rocker bush in rocker and on spindle. The minimum and maximum fit allowances will be found on the clearance chart. Check up rocker pads for wear. If wear is only slight they can be stoned smooth, but if contour of pad is badly affected a new pad should be riveted in rocker. Check up ball end in rocker and socket on tappet rod for any signs of pitting or undue wear. If pitted, however slightly, renew. Should cylinder head have been at all difficult to slide up cylinder holding studs when engine was being dismantled, the holes in head which take these studs should be checked. These holes sometimes close in slightly at the top end and should be eased out to the original diameter.

The cylinder head should be checked for distortion as follows :—

The cylinder head should be placed on a surface plate and distortion should be checked by inserting feelers between face on cylinder head and surface plate. All burrs, etc., should be removed from face of cylinder head before carrying out this operation. Feelers should be inserted at points midway between cylinder holding down stud bosses. The head should be held down tightly to surface plate while carrying out this operation, and should be checked between all four bolt bosses.

The maximum distortion allowable measured in this manner is 0·025

in. and any head showing more than this should be scrapped. Heads showing between 0·010 and 0·025 in. can be used provided the seating for the copper and asbestos washer is trued up. This seating can be trued up by skimming in a lathe or can be lapped, using an old cylinder as a lap. Heads showing less than 0·010 in. can be considered serviceable without any rectification.

Important. In no case should more than 0·012 in. of metal be removed from seating for truing up purposes.

The rocker bracket bolts (aluminium heads only) should be inspected in accordance with Ground Engineers' Notice No. 40 of 1931.

The valve rocker platforms (aluminium heads only) should be inspected according to Ground Engineers' Notice No. 32 of 1932.

Cylinder Heads (Aluminium Bronze Type)

The instructions concerning the aluminium type are generally applicable, except with regard to the valve seatings. In the aluminium bronze type the seatings are formed directly in the material of the head, and the permissible amount of cuttering of the seatings is shown on the manufacturer's drawing.

Pistons

These should be checked for cracks, wear in gudgeon-pin bores, wear in ring grooves, and wear on diameter. Minimum and maximum dimensions are given on the clearance chart. Piston rings should be checked for blowing by loss of spring or excessive gap. If piston is inserted in the cylinder, the crown can be used for squaring up rings when checking gap. Fit piston ring to piston for checking ring groove clearance. Before doing this make sure that the ring grooves are free from carbon.

See notes under " Cylinder " *re* oversize replacements.

If on dismantling early engines, pistons Part Nos. 800-15A or C are found, opportunity should be taken during top overhaul to modify them as follows : The skirt of the piston should be shortened to make the piston an overall length of 70 mm., measured from the crown. The excess of metal can be removed by hand tools or turned off. The corner of the skirt should then be given a 5 mm. radius and any sharp corners where cross webs join the skirt, should be carefully radiused out. Any piston weighing less than 24 ozs. 7 drams after shortening must be replaced by a new part.

Gudgeon Pins

Check up for wear and cracks. Check fit in connecting rod against sizes given in clearance chart.

If on dismantling very early engines, gudgeon pins, Part No. 1300/17, gudgeon pin washers, 1300/18, and circlips, 1300/19, are found, they should be replaced by :—

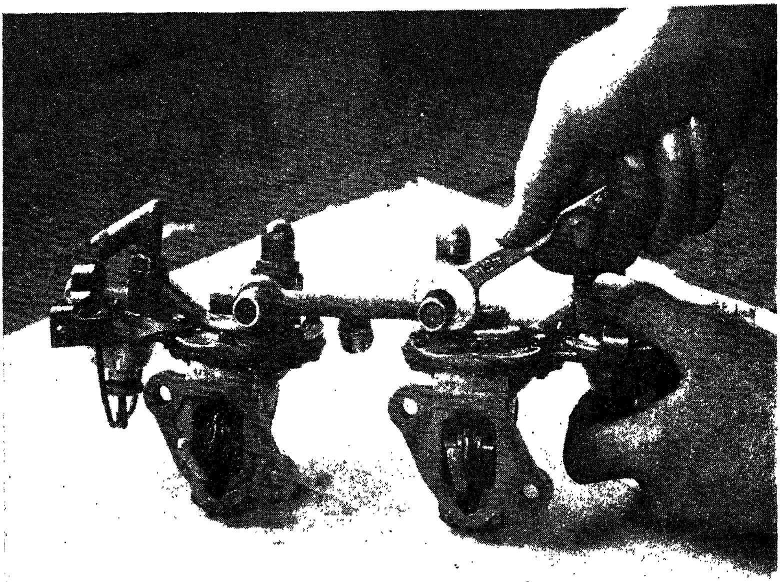


Fig. 20.—DISMANTLING THE DE HAVILLAND A.C. FUEL PUMP.

Gudgeon pins, 800/17.
Gudgeon pin washers, 800/18.
Gudgeon pin circlips, 800/19.

The old type gudgeon pin can be easily identified as it is reduced in diameter at the ends to receive washer and circlip. The new type is the same diameter throughout.

Cylinders

Check up for wear, ovalness or scoring in bores.

The manufacturers have repair schemes whereby cylinders can be ground 0·005 in. oversize and provide special piston rings to be used with the standard size piston. Also there is a scheme for grinding 0·010 in. oversize and the fitting of special oversize piston and rings.

Connecting Rod

If the connecting rods are of the "Y" alloy type and have embossed lettering on the web portion of the "H" section they should be inspected in accordance with Ground Engineers' Notice No. 29 of 1933.

Reassembly

The following parts should be replaced by new :—

Dermatine ring under cylinder base.
Copper and asbestos washer between cylinder head and cylinder.
Hallite washers on induction ports.

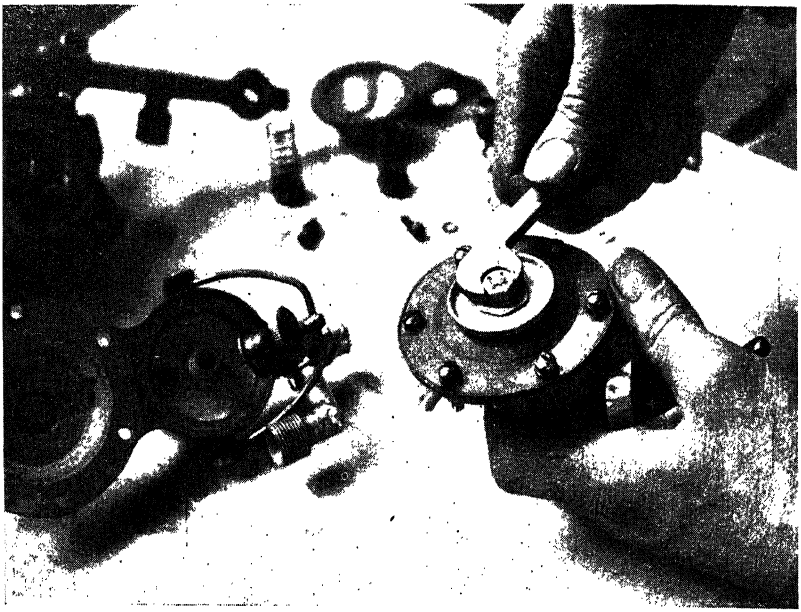


Fig. 21.—ASSEMBLING THE DE HAVILLAND A.C. FUEL PUMP.

When tightening top nut on diaphragm pull rod, enter the six screws through diaphragm into body. This will hold diaphragm in correct position and facilitate final entry of screws.

Copper and asbestos washers on exhaust ports.
Dermatine ring in valve gear casing.
Joint rings at top and bottom of tappet casing tubes.
Hallite washers between carburetter and induction manifold.

The following points should be noted during assembly :—

1. All parts should be freely oiled during assembly.

2. Scraper ring should be nearest the gudgeon pin and the land of the ring towards the crown of the piston.

3. On the Gipsy II, before metering pin is replaced in valve rocker bracket, the bore which takes this pin should be cleared of all jointing material, and pin should be a free fit when in place. This pin should be fitted before heads are replaced on engine and should be held by screwing plug in temporarily until oil pipes are fitted.

4. When reassembling cylinder heads, use the valve spring compressor to hold collars down while replacing collets.

5. Before reassembling any parts on crankcase, this should be thoroughly cleaned. Remove drain plug under sump and allow all dirty oil to drain out. Remove pressure oil filter and casing from sump. Clean crankcase externally with petrol. Clean pressure and suction filters and casing.

6. Pistons for the Gipsy II and III were originally selected into three weights and marked by the affix "X," "Y" or "Z" to the part number. Tests have proved that this selection is unnecessary to the smooth running of the engine and the various weights can be mixed in the same engine if required.

7. When refitting circlip on gudgeon pins, use the circlip expander. Circlips when fitted must be a tight fit in groove in gudgeon pin. If at all loose they must be renewed.

Fig. 22.—ASSEMBLING THE DE HAVILLAND A.C. FUEL PUMP.

When fitting valves and valve caps, make sure that valve is in guide in cap before tightening cap down.

8. Piston ring gaps should be spaced equidistantly before fitting to cylinders. When replacing cylinders, use the piston ring clamp to hold piston rings in place. As cylinder is pushed down, the clamp will be pushed off piston and can be withdrawn before cylinder is right down in place.

9. While cylinder heads are being put down, make sure that bridge pieces, thin and thick washers, and nuts are put in place. Cylinder nuts should be screwed down just sufficiently to hold heads and the heads should be lined up by a straight edge against the inlet port facings. The cylinder heads should then be tightened down by tightening nuts on opposite corners alternately. The nuts, finally, should be screwed down firmly and evenly.

10. When replacing valve gear covers the stirrup screws should be tightened down just sufficiently to make an oiltight joint between cover and casing. Do not strain cover by tightening screws unnecessarily.

11. Nuts on inlet and exhaust manifold should be tightened up progressively. Do not strain unnecessarily when tightening. This will only bend flanges.

12. When replacing airscrew the following points should be noted :—

The nuts on airscrew bolts should be tightened up alternately on opposite bolts. The amount of thread should be checked to ascertain that the nuts are not bottoming on end of thread before airscrew is tight.

When assembly is complete, the engine should be filled with clean oil and run at about 800 r.p.m. for about fifteen minutes to allow oil to circulate before being opened up to full throttle.

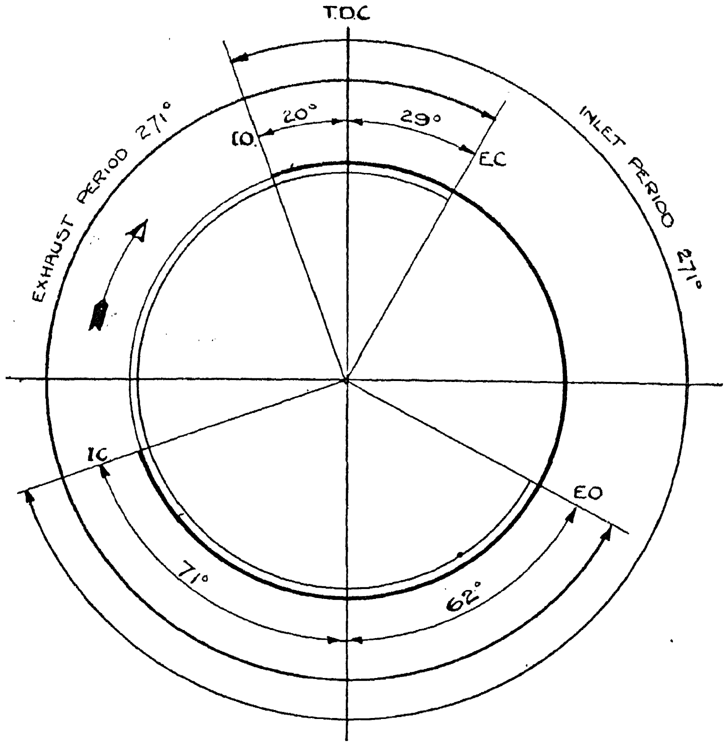


Fig. 23.—VALVE TIMING DIAGRAM (CRANKSHAFT) COLD.

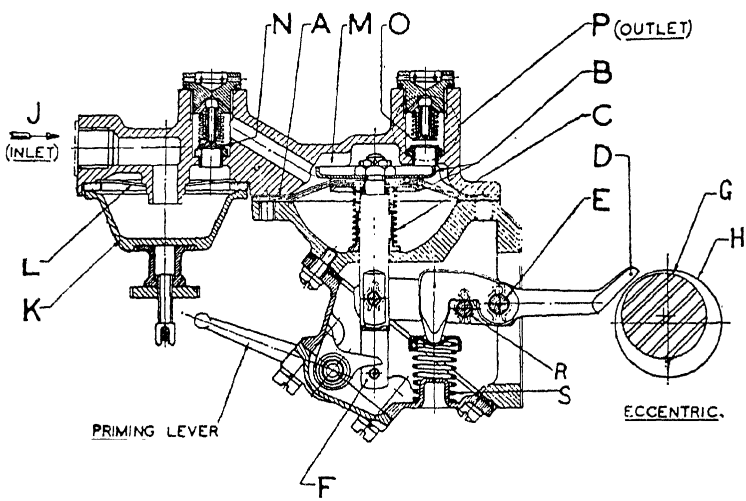


Fig. 24.—THE D.H. A.C. FUEL PUMP.

After 450 Hours' Flying

The engines should be removed from the airframe and given a complete overhaul.

Note. Gipsy III engines subsequent to No. 3488 or in the case of engines which have been completely overhauled by the makers, modified and brought up to date, can have this running period extended to 500 hours.

Magnetos, carburetter (and fuel pumps if fitted) should also be overhauled.

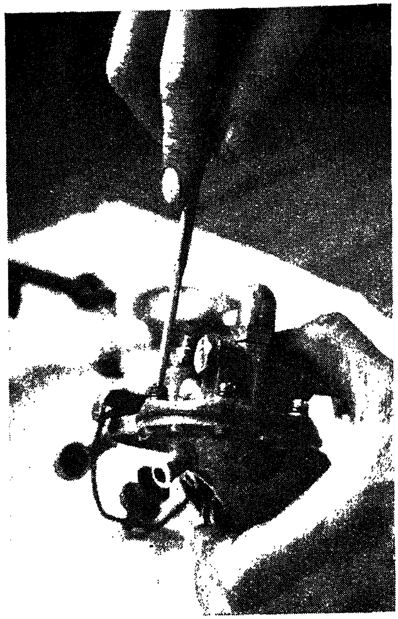


Fig. 25.—BEFORE TIGHTENING THE SIX SCREWS HOLDING TOP COVER, PUSH DIAPHRAGM PULL ROD UP.

Magneto Timing

Note. In order to provide for the use of fuels with a low H.U.C.R. (highest useful compression ratio) figure coupled with low r.p.m. at full throttle on the climb it is considered advisable to reduce the magneto timing of the engine.

The original advance was 40 degrees *before top dead centre.*

This should be reduced to 34 degrees *before top dead centre.*

This new advance position should be marked on the front cover and magnetos should be retimed to this at the first opportunity. The front cover should be re-marked for magneto advance at a point 38 mm. before top dead centre measured round the periphery, and the existing magneto advance marked approximately 44·5 mm. should be filed out. The engine number plate should be altered accordingly.

THE D.H. A.C. FUEL PUMP (Fig. 24)

Operation

By revolving shaft (G) the eccentric (H) will lift rocker arm (D), which is pivoted at (E), and which pulls the pull rod (F) together with diaphragm (A) held between metal discs (B), downward against spring pressure (C), thus creating a vacuum in pump chamber (M).

Fuel from the tank will enter at (J) into sediment bowl (K) and through strainer (L) and suction valve (N) into pump chamber (M). On the return stroke spring pressure (C) pushes diaphragm (A) upward, forcing fuel from chamber (M) through pressure valve (O) and opening (P) into the carburetter.

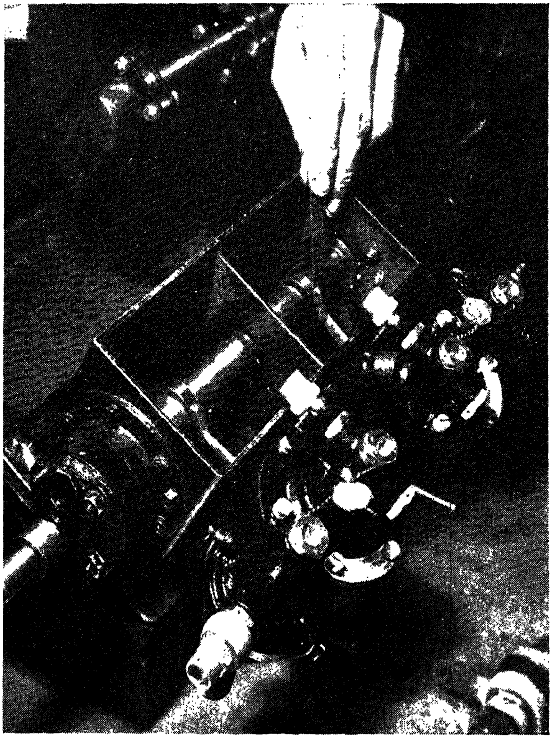


Fig. 26.—THERE SHOULD BE 0·035 TO 0·045 IN. FURTHER MOVEMENT BETWEEN STRIKING PAD AND ECCENTRIC IN FULL LIFT POSITION.

This can, of course, only be conveniently checked in bench test rig.

When the carburetter bowl is filled, the float in the float chamber will shut off the inlet needle valve, thus creating a pressure in pump chamber (M). This pressure will hold diaphragm (A) downward against the spring pressure (C) and it will remain in this position until the carburetter requires further fuel and the needle valve opens. The rocker arm (D) is in two pieces, the outer operating the inner one by making contact with pin (R) and the movement of the eccentric (H) is absorbed by this "break" when fuel is not required.

Spring (S) is merely for the purpose of keeping rocker arm (D) in constant contact with eccentric to eliminate noise.

Some fuel pumps are fitted with a hand primer. Operation of the lever of this pulls the pull rod (F), together with the diaphragm (A), so priming the carburetter with fuel for starting the engine.

A gland is fitted round pull rod (F) to stop any fuel which may leak through diaphragm (A) from running into the engine. An adaptor is fitted into the wall of the chamber immediately below diaphragm. A drain pipe should be connected up to this adaptor, so leading any leakage clear of the aeroplane cowling.

Instructions for Dismantling and Reassembly

Dismantling is a straightforward operation, but care should be taken to avoid mixing up parts of various pumps when in the dismantled condition.

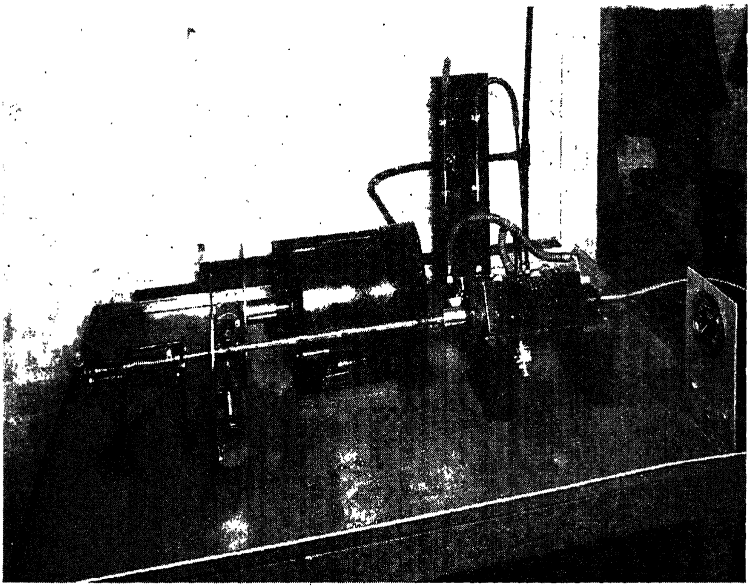


Fig. 27.—BENCH TESTING RIG.

Showing electric motor, friction disc, variable speedgear, revolution indicator and U tube for adjusting pressure head. The supply tanks are under bench.

The following points should be watched during reassembly :—

When tightening top nut on diaphragm pull rod, enter the six screws through diaphragm into body. This will hold diaphragm in correct position and facilitate final entry of screws.

Do not tighten this nut down too tightly. This should only be sufficiently tight to avoid leakage of fuel through centre of diaphragm.

When fitting valves and valve caps, make sure that valve is in guide in cap before tightening cap down.

The springs are of different types for the inlet and outlet valves. The stronger spring is fitted to the inlet valve.

Before tightening the six screws holding top cover, push diaphragm pull rod up until the edge of large washer (B) is against lower edge of valve seat and keep in this position until screws are finally tightened.

Should rocker arm (D), rocker links or pull rod (F) have been renewed, the pump will have to be checked as follows: The assembled pump should be fitted on a test rig or an engine. The camshaft should be turned until the eccentric (H) is in the position of full lift. A further movement (measured between the striking pad of lever (D) and eccentric (H)) of 0·035 to 0·045 in. should then be obtained. To obtain this, it may be necessary to fit a washer of different thickness between the small disc (B) and the shoulder on the pull rod (F).

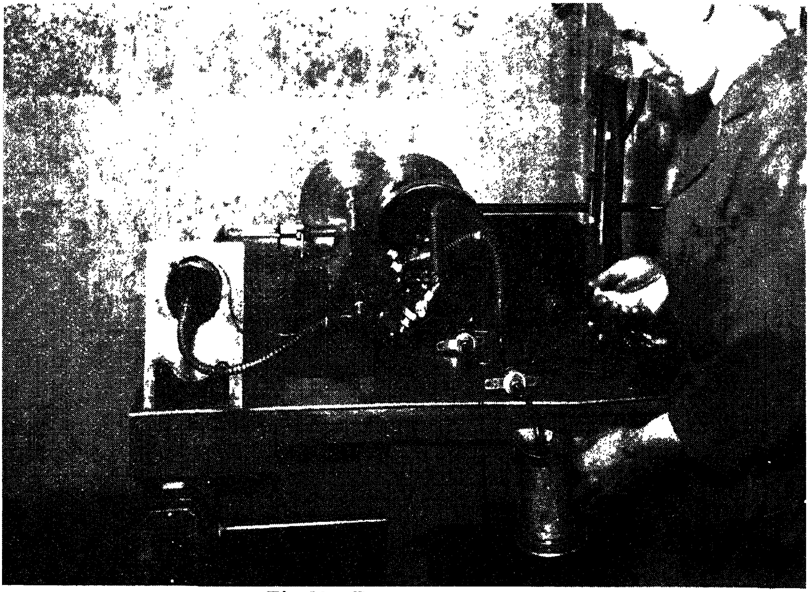


Fig. 28.—BENCH TESTING RIG.
Showing tester taking check reading of delivery with stop watch.

The diaphragm spring (C) is somewhat similar in appearance to the rocker arm spring (S). To avoid mistakes in reassembly, the diaphragm spring (C) is painted blue, and care must be taken that these springs are fitted in their correct positions.

MAINTENANCE OF WHEEL BRAKES ON AEROPLANES

By S. Cockerell

MECHANICALLY OPERATED BRAKES

Maintenance

THE maintenance of Bendix brakes will consist of lubrication, inspection for wear, adjustment and checking all turnbuckle nuts for locking. During inspection the cable should be examined for fraying, especially where it passes through the outer flexible cables and around all guide pulleys. The cable should be treated throughout its whole length with a medium-bodied graphite grease. Each guide pulley should be quite free and oil should be applied to the centre pins ; oil should also be given to the rocker shaft bearings and fork joints, whilst the ratchet pawl and operating button should be lubricated. A little graphite grease on the quadrant teeth of the hand control and at each end of the compensator bar will assist in giving easy operation and will facilitate return to the "off" position. Between the back plate and the shoe inner edge an application of the special zinc oxide grease supplied by the manufacturers should be made on the projections which guide the shoes. Care should be taken to avoid a surplus of grease in the brake conduit, as excessive grease is liable to work through and get on to the brake shoe liners, rendering them unserviceable.

Adjustments

Adjustment of the brakes will be necessary in order to take up wear of the brake shoe liners, and at the same time take up any cable stretch that has occurred ; two simple adjustments are provided for this purpose : (i.) at the ends of the control cables consisting of a turnbuckle for each brake unit, (ii.) shoe adjustment at the star wheel on each brake unit, which is reached through a slot in the back plate by means of a small flat steel tool or a suitable screwdriver.

Adjustments in Service

Secure the rudder bar in the central position and jack up the aeroplane wheels, then examine the wheel bearings ; excessive wear here will make any brake adjustment useless until the fault is rectified. Having passed the wheel bearings as satisfactory, the brake shoes should be fully expanded in the drums by means of the star wheels in each unit. Apply a slightly greater pressure to the brake control than is normally used in

ordinary brake application, return the lever to the " off " position, when the turnbuckles on each control cable end should be adjusted until any slackness in the cable is eliminated ; the cables, however, should not be in tension and the brake shoe cam lever should be at rest when the control is in the " off " position. The star wheels should now be turned an equal amount at each side (usually six teeth will be found correct) until the clearance between the drum and the secondary shoe is 0·008 in. measured by means of a feeler gauge through the slots in the back plate. The brake should now be applied until the shoes just allow the wheels, each requiring the same effort, to be turned by hand ; any difference may be caused by stiffness in the compensator or lack of grease in the cable conduits. Any fault in this direction should be located and corrected, finally testing the adjustment by full application of the brake, when both wheels should be locked. Test again to ensure that both wheels are free when the brake control is in the " off " position.

Brake Shoe Renewal

When the liners have worn badly and relining is necessary, it is advisable to replace the shoes ; the shoes are supplied lined and correctly ground to a jig. Shoes that are lined without special appliances are liable to be distorted and the uneven surface of the liner will render the brakes uncertain in action. Given correct adjustment, the proper functioning of the brakes is entirely dependent upon the true surface of the liners and the suitability of the linings. When brake shoes are removed the springs and their location must be noted in order to ensure their correct replacement. The use of a hooked tool will assist in the removal and replacing of the springs. After fitting replacement shoes the wheel and drum should be placed in position and the brakes adjusted as described above, but first the shoes should be tested for correct location ; this is ascertained by the use of a feeler gauge introduced through the slots in the back plate at which points the clearance should be 0·008 in. between the secondary shoe liner face and the drum. Should the tip of the shoe at either end differ from this measurement the eccentric stop should be turned and the shoe centralised after which the locknut should be tightened up. In the small sizes of brake shoes the eccentric stop is not fitted, but otherwise the adjustment is the same.

Note

Grease- or oil-impregnated liners must be discarded ; do not wash liners in paraffin.

Lubricate flexible cable conduits but avoid a surplus of grease.

Do not allow water, and particularly sea water, to remain in the drums, as this will attack the magnesium alloy. Keep the channel in the torque ring of the back plate clean and free from surplus grease.

Scored and damaged drums should be replaced by new ones.

DUNLOP PNEUMATIC BRAKES

Adjustment to Relay Valve Control

During adjustment of the valve the air container gauge should register a pressure of 80 lb. per sq. in. If prior to adjustment it is found that air pressure is admitted to either of the brake units without any movement of the brake-actuating lever having been made, it will be due to dirt on the valve seat, the valve mechanism having been screwed in too far or the diaphragm may be distorted. To adjust the valve slacken the supply pipe union nut, whilst holding the screwed connection, then turn the connection in an anti-clockwise direction until the air is exhausted ; this will be indicated by the pressure gauge. Tighten the union nut and whilst doing so hold the screwed connection to prevent alteration of the setting. In the event of no alteration of pressure taking place during adjustment, a new diaphragm is necessary. The air container should now be charged to the full working pressure, *i.e.*, 200 lb. per sq. in., and the brakes applied by means of the operating lever ; if either brake now fails to operate, the valve connection should be turned in a clockwise direction, observing the precautions mentioned above, adjustments being made on each side if necessary until the two wheel units are working evenly. In cases where the brake pressure fails to reach 80 lb. per sq. in. (when the air container pressure is at the normal working pressure) the compression chamber requires resetting. To adjust the chamber remove the small nuts at the top of the valve, withdraw the chamber along the pins about $\frac{3}{8}$ in. ; now apply the hand control lightly, at the same time push the chamber back into position and replace the nuts, locking all nuts when the correct adjustment has been obtained.

Maintenance of System

The maintenance of this type of brake consists of slight adjustments after some usage, cleaning the air filter periodically, attention to the air line connections, and possible adjustment to the relay valve. The brake control of the Bowden type is provided with an adjuster to take up slack in the operating cable as slackness would result in loss of movement at the valve plungers. Pipe joints should be tested for air leaks by means of soapy water applied at the joints while the pressure in the system is at the maximum. On removing or tightening the pipe connections to the relay valve unit, the valve hexagon should be held firmly to prevent alteration of the control adjustment. Rubber rings for pipe connection jointing should be replaced when disturbed, as they are inclined to perish during service. In the event of brake blocks becoming greasy or impregnated with oil a new replacement block must be fitted. If the protective coatings on the magnesium alloy parts have become damaged, the parts affected must be treated with cellulose enamel.

Removal of Brake Blocks and Expansion Chamber

The wheels must first be removed, when the spring clips which hold the blocks in position will be seen. Mark the position of the blocks with a drop of coloured cellulose enamel in order to ensure correct re-assembly, after which the clips may be removed and the brake blocks lifted off the ring. When replacing a block with a new one a clearance of $\frac{1}{32}$ in. must be allowed between the butt ends of adjacent blocks. If it is found necessary to remove the expansion chamber this must first be disconnected from the pipe line and rolled off the rim of the channel at a point diametrically opposite the connection ; a metal lever must not be used for this purpose.

PALMER PNEUMATIC BRAKES

Maintenance of Pedal Unit

As in all pneumatic-type braking systems, the presence of any foreign matter must be avoided in the pipe lines to prevent valve trouble caused by particles of metal, etc., becoming lodged under the inlet or exhaust valves with consequent leakage. The rubber elements in these units should be replaced periodically, especially in hot climates, as they are apt to deteriorate after they have been in use for some time. The following points will assist in locating faults which may arise :—

(i.) Insufficient air at either wheel unit when the pedal is operated indicates the presence of some foreign matter in the system between the inlet valve on the pedal unit and the wheel unit connection, or it may be due to the sticking of the inlet valve.

(ii.) Excessive air at the wheel unit is due to the incorrect setting of the adjusting screw so permitting the inlet valve to pass air in excess of the permissible maximum pressure. To reduce the pressure, the screw must be rotated in a clockwise direction, and *vice versâ* if an increase of pressure is required. A further adjustment to increase the air pressure may be obtained by screwing down the nut under the diaphragm, thereby compressing the spring.

(iii.) Continuous air leakage on the pedal unit when the pedal is not operated indicates faulty inlet valve or dirt on the valve seat.

(iv.) A continuous air leakage at the pedal unit when the pedal is depressed may be caused by a defective exhaust valve, insufficient load on the valve spring, a defective diaphragm or the presence of dirt, etc., on the exhaust valve seat.

Maintenance of Differential Control Unit

The maintenance of this unit can be divided into two sections, *i.e.*, mechanical adjustment and pressure setting. Units may with advantage be removed and tested on a properly equipped bench furnished with a fixture on which the unit can be mounted, a compressed air container with

pressure gauge and an improvised hand lever with Bowden control for operating the master regulating valve. The air container should be capable of withstanding a pressure of 200 lb. per sq. in. and fitted with a gauge, calibrated 0–200 lb. per sq. in., to indicate the contents of the container. The units should be connected together in order that the test conditions will be similar to those existing when operating in an aeroplane. As most of the adjustments can also be made with the units installed in the aeroplane the following instructions will apply in both cases. *Note.*—It must be remembered (for safety purposes) throughout the operations that it is most important for the air supply to be shut off before any adjustments are commenced. In cases where a shut-off cock is not provided in the system the air must be released from the container :—

(i.) *Bowden Control Stop and Adjusting Rod.*—First apply the hand-operating lever, this will cause both lower pistons to be fully extended when the combined clearance between the adjusting screws and the piston ends should be $\frac{1}{32}$ in. If the clearance is less than this amount the two screws should be adjusted to give this clearance with both screws turned an equal amount. The cable adjustment should have $\frac{5}{32}$ in. lost movement before the load is supplied to the master regulating valve.

(ii.) *Air Leakage at Differential Unit.*—This can be caused by two defects, *i.e.*, a leaking master regulating valve or a loose sleeve which secures the exhaust valve seat and its rubber sealing washer; these defects may be remedied as follows :—

(*a*) *Leaking Master Regulating Inlet Valve.*—Shut off the air supply and release the air from the unit by full application of the hand lever, then remove the centre end cap which gives access to the valve. Using the special tube spanner supplied, slacken the gland nut about half a turn, then insert the special screwdriver inside the spanner and, holding the latter, turn the screwdriver in an anti-clockwise direction for about half a turn. The gland nut should now be tightened whilst holding the centre screw with the screwdriver. No definite amount of adjustment can be given, as this varies and must be ascertained by experiment. Before replacing the end cap examine the fibre washer, and if defective a new one must be fitted. Replace the end cap and test the unit.

(*b*) *Loose Sleeve.*—First remove the Bowden cable control assembly and then remove the small setscrew which positions the sleeve; withdraw the plunger and adjusting rod and the exhaust valve. The sleeve can now be tightened by means of a strip of steel shaped to fit the end. Another hole must now be drilled and tapped in the new position to take the small setscrew, when the exhaust valve can be replaced and the setscrew inserted; the setscrew is also employed as a stop to prevent the exhaust valve falling out. Care should be taken to replace the valve

tappet if this has been dislodged. This must be replaced with the spigot inwards, the operation being facilitated by using a small amount of grease on the end of a piece of wood. The Bowden cable assembly can now be replaced and the unit tested.

Brake Unit Pressure Adjustment

The air pressure to the two wheel brake units should be equal and adjustment of the two differential control inlet valves can be made in a similar manner to that described above (leaking inlet valve). To increase the pressure the housing of the inlet valve should be turned in a clockwise direction and *vice versâ* to decrease the pressure. Defective valves should be replaced with a complete new valve. There are three exhaust valve springs in the differential control unit, one in the master regulating valve and one in each of the differential control valves. It is important to ensure that the correct springs are fitted should the unit be dismantled, as the respective tensions vary according to the brake requirements of the particular type of aeroplane.

Defective Rubberised Sleeves

These sleeves are mounted one on each of the differential valve unit lower pistons and may require renewal owing to deterioration of the material from which they are constructed. In the case of a defective sleeve the differential control end casting should be removed and the operating link pin should be withdrawn; the piston assembly can now be pushed out of the cylinder. The damaged sleeve should be removed and a new one fitted in its place, care being taken not to rotate the piston crown during the tightening of the nut. It is very important to ensure that the periphery of the sleeve is concentric with the piston. On re-assembling the piston and sleeve the inside of the sleeve should be lubricated with similar fluid to that used for operating hydraulic systems. Before replacing the end casting make sure that the turned-over edge of the sleeve rests evenly on the end of the cylinder casting and that the piston rod is in its correct position for connecting to the operating link. The end casting assembly should now be replaced and the unit tested.

Maintenance of System

Should any fault arise in the working of the system after correct assembly, the presence of foreign matter may be suspected, such as dirt or metal filings, etc. Oil and water resulting from condensation will also cause faulty operation of the system by the deterioration of the rubberised elements, corrosion and clogging of valves. It is therefore essential that the drain plug (situated in the bottom of the air container) is removed frequently. The filter gauze, which is housed in the end casting of the differential control unit, should be cleaned periodically. The air container inflation valve is of the usual Schrader type, and should be examined

occasionally for serviceability. Leakage occurring at this valve should be remedied by cleaning or, if the rubber element is defective, a new valve should be fitted. Fibre washers employed on the unions of the system which have hardened or split in service should be renewed by new ones of the same material.

PALMER HYDRAULIC BRAKES

Maintenance of Pedal Unit

Cleanliness of the internal working parts is essential to obtain satisfactory functioning of the unit. Whilst all metal parts may be washed in petrol, the rubberised components should be cleaned in methylated spirits. These components must not be allowed to come into contact with any paraffin, mineral oil, etc., nor must any other fluid be used in the system than that specified by the manufacturers. When a pedal unit is dismantled the following items should be examined :—

(i.) Pedal rollers and pins for wear.
(ii.) Tension springs for loss of strength.
(iii.) Spring-loaded valve for stem alignment.
(iv.) Valve seat for wear.
(v.) Valve spring for breakage or weakening.
(vi.) Rubberised sleeve for deterioration.
(vii.) Screws and threaded holes for stripping of threads.

Defective operation may be caused by any of the above. Some indication is given of a faulty unit by a rapid rise in the level of the reservoir fluid and lack of pressure at the wheel unit ; this is due to a faulty valve, see (iii.), (iv.), (v.) above. The rubberised sleeve should be perfectly aligned when mounting it in position ; this sleeve may deteriorate, especially in tropical climates.

Priming the System

The main object of priming is to expel all the air from the closed circuit and replace it with brake fluid, otherwise there will be loss of effective movement at the pedal. The apparatus for priming consists of a bulb (*see* Fig. 1), a length of rubber tube and some round wooden plugs for blanking pipe ends. A supply of the correct brake fluid will be necessary and a small syringe will be found useful for topping up purposes. All the equipment used must be kept absolutely clean and free from dirt. The description given below will serve to indicate the method adopted in priming.

(i.) Jack up the axle and remove the landing wheels.

(ii.) Remove one of the pedal units and uncouple the pipe connections, plugging the pipe ends.

(iii.) Turn the pedal unit with the connections uppermost and connect the charged bulb apparatus to the connection used for coupling the unit to the wheel units. With the bulb held vertically operate the pedal unit

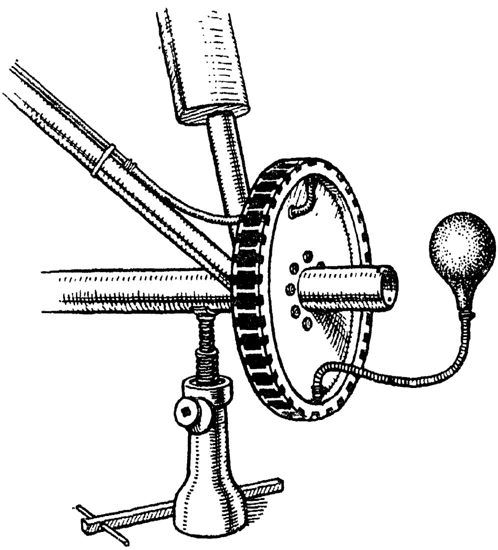


Fig. 1.—BULB APPARATUS FOR PRIMING.

by slow successive strokes, followed by a few rapid strokes. This should be continued until all air inside the pedal unit has been expelled. Remove the bulb apparatus.

(iv.) Mount the pedal unit on the rudder bar with connections uppermost.

(v.) Blank off the tubing with a clamp at the T union leading to the other pedal unit. Remove the plug (already inserted) in tubing leading to the reservoir and connect the priming bulb at this point; prime the pipe line to the reservoir, until bubbles no longer appear in the reservoir. Remove the bulb and replace the pipe on pedal unit connection after topping up the unit with fluid by means of the syringe.

(vi.) Refill the bulb with fluid and connect to the wheel unit as shown in Fig. 1 after removing the plug in the end of the priming connection. Raise the remaining plugged pipe at the pedal unit as high as possible; remove the plug and squeeze the bulb slowly at first, then more rapidly until the fluid alone emerges from the pipe line. The pipe end can now be coupled to the pedal unit, taking care to top up at the unit connection with fluid, ensuring that no fluid is lost during the coupling operation.

(vii.) Rotate the pedal unit on the rudder bar until it is in the desired working position and tighten the clamp securing the unit to the bar. With the reservoir half full of brake fluid, operate the pedal several times until it is seen that air bubbles cease to rise through the fluid in the reservoir.

(viii.) The bulb should now be removed from the wheel unit connection and the screw replaced. Replace the landing wheel.

(ix.) The same procedure as outlined above must be adopted in priming the remaining half of the system.

(x.) Throughout the operations care should be taken to prevent fluid from reaching the brake shoes, as it is essential that these should be perfectly dry.

Maintenance Notes

Maintenance of this system consists chiefly of attention to pedal units and priming operations ; both of which have been dealt with above. There is, however, a certain amount of adjustment to be made to compensate for wear on the brake shoes, this may be effected by the fitting of a rubber band under the expansion chamber. An alternative method is to wrap a layer of insulation tape around the annular channel in order to obtain the original clearance between the shoes and the drum, which should be from 0·015 in. to 0·020 in. Whenever a pipe line connection is removed or an adjustment made involving the loss of fluid the system will require priming.

VICKERS PNEUMATIC WHEEL BRAKES

To obtain maximum efficiency of the brakes it is very important to ensure that all adjustments to the components of the system are carefully and correctly made. The components are constructed from light alloys suitably treated to protect them against corrosion, and it is important that this protection is not damaged when making adjustments to, dismantling or assembling them. If for any reason the protection of a component has been damaged, necessary steps should immediately be taken to rectify the damage. During work absolute cleanliness must be observed to prevent dust or other foreign matter entering the system and interfering with the functioning of the valves. Water and oil must also be excluded from the system, which entails periodically draining the air reservoirs and cleaning the air filters.

Pipe Lines

The pipe lines and their connections should be periodically examined for leakage or damage ; the connections must be kept tight and all joints tested for leakage by applying a water/soap solution. Particular attention should be given to the pipe line installation to ascertain that damage is not being caused by corrosion, rubbing or vibration.

Bowden Transmission

These transmissions require occasional lubricating and should be examined for ease of functioning and possible damage. The transmission must function with ease in order to facilitate the release of the brakes. The cables should rest in a position which avoids sharp bends and should they show signs of fraying they should be replaced by new ones.

Wheel Brake Units

The wheel brake units require little attention, but should be occasionally examined, cleaned and adjusted. All working parts should be sparsely lubricated at their appropriate oil holes with an anti-freezing oil. Over lubrication of the aeroplane wheel bearing must be avoided to prevent lubricant being thrown on to brake shoe linings. Brake shoe linings which have become hardened by grease or have been scoured should be

replaced by new ones ; in the event of scoured linings attention should be given to the drum of the aeroplane wheel.

Adjustment of Brake Shoes

The correct adjustment of the brake shoes is important as too small a clearance will, of course, cause friction, while too large a clearance will cause an excessive consumption of the air reserve. The adjustment and testing of these components are simple operations ; the following method will be found effective :—

(i.) With the aeroplane wheels on the ground and working on one unit at a time, adjust the link between the piston and the cam lever so that a travel of 0·2–0·25 in. is obtained at the end of the cam lever when lifted by hand in an upwards direction.

(ii.) Operate the parking brake to its fullest extent and ascertain that there are no air leaks at the inlet adapter or past the cup washer situated on the head of the piston. Minor leaks which cannot be heard will be indicated by a gradual fall of the pressure gauge reading.

(iii.) Operate the hand control lever several times and ensure that the brake unit has a continuous action and quick release.

(iv.) After adjusting the brake units, jack up the wheels and ensure that they are quite free to rotate when the brake has been released.

Main Control Valve

The normal maintenance of this component consists of occasionally lubricating the working parts through the oil holes provided with an anti-freezing oil, and frequently removing the horsehair air filter and cleaning it. The filter should be washed in petrol and allowed to dry ; rag should not be used and care must be taken when replacing it to prevent dirt, etc., entering the component. The adjustment and testing, however, of this component is an intricate operation needing great care to obtain satisfactory results. For this reason a full description of the operations is given below. After fitting any replacement parts or dismantling for cleaning purposes, the unit should be carefully assembled on the bench and then mounted into the braking system. The test should be made at a greater air pressure than is normally permitted, and, after successfully passing, re-adjusted to suit the pressures as recommended for the aeroplane in which the system is installed.

The following is the sequence of operations for testing and adjusting the component. The bracketed letters refer to Fig. 15 (page 567), Vol. I. under the heading " Vickers Pneumatic Brakes " :—

(i.) Create an air pressure of 200 lb. per sq. in. in the supply reservoirs ; this pressure should be maintained throughout the operations.

(ii.) With the rudder bar of the aeroplane in the central position, apply the parking brake and obtain a reading of 100 lb. per sq. in. on the dual gauge. Should the pressure readings be unequal they should be equalised as explained below, but it must first be ascertained that there are no

leaks in the system ; all joints should be tested with a water/soap solution and any defects rectified. Should it be found that, with the controls stationary, the pressure reading of either pointer increases, it will indicate that the inlet valve is faulty and requires replacing with a new one.

(iii.) After examination and, if necessary, rectification of any of the above defects, the pressures should be equalised by means of the eccentric adjusting bolts (C) ; loosen the locknuts and with a screwdriver slowly rotate the bolts until an equal pressure reading is obtained on the gauge. Should the movement of the eccentric bolts be insufficient to complete this adjustment, the pressure should be released from the system and the valve (F) adjusted either nearer to or further from the diaphragm (M) as required ; very little movement is required for this adjustment and it can only be determined by experiment. It is important to note that the valve clamping nut must be tightened before air pressure is again applied.

(iv.) After obtaining equal pressures a test should be made to ensure that the brake release is instantaneous. Release the parking brake and the pressure readings should show a quick drop to zero. If the drop is gradual it will indicate that the valve has been adjusted too close to the diaphragm and is preventing the exhaust valve from functioning correctly.

(v.) With the above adjustments completed and satisfactory, the component should be adjusted to conform with the maximum pressures laid down for the particular aeroplane. These pressures are dependent on the amount of downward movement of the lever (B) and are determined by the adjustable stops (D). In the first place set the parking brake, after which the hand lever master control should be set.

(vi.) The brakes should now be tested for continuous action. With the rudder bar in the central position, operate the hand lever master control several times, observing the pressure gauge ; the reading should rise and fall evenly and progressively with the application or release of the control.

(vii.) Test for differential braking. Operate the hand lever master control and move the rudder bar to one side, when the pressure reading of the side involved should show a quick drop to zero, whilst the other side should remain constant. On moving the rudder bar from side to side, the pressure readings should rise to a pressure (governed by the master hand control) and fall to zero alternatively.

(viii.) On the successful completion of all the above adjustments and tests, a final test should be made by means of the parking brake. Apply the parking brake, noting the pressure reading, and allow to stand for a period, say two hours. The pressure should remain constant over the period.

VICKERS HYDRAULIC BRAKES

To retain the maximum efficiency of these brakes, it is very important to ensure that air, grit or other foreign matter which can interfere with the correct functioning of the non-return valves is not present in the

system. It is therefore necessary to observe absolute cleanliness when making any adjustments, filling the reservoir, etc. The components of the system are suitably treated to prevent corrosion and care should be taken to protect the coating during the various adjusting operations, etc.

The reservoir should be kept three-fourths filled and care taken to ascertain that the system is free from air. To fill the system and at the same time expel the air, open the air-release valve on the wheel brake units and circulate the liquid throughout the system by using the hand lever as a pump ; when it is seen that only pure liquid is being emitted from the air-release valves they should be closed (while still pumping) by screwing them hard down on to their seats.

It is of great importance to ascertain that there is no leakage of the liquid ; all joints must be kept tight and periodically examined whilst the system is under maximum pressure.

Wheel Brake Units

These units require little attention, but should be kept clean and the working parts occasionally lubricated with an anti-freezing oil. The shoe linings should be periodically examined and replaced as required. When making this examination, the pull-off springs should also be examined to ascertain that they have not become tired, fractured or distorted ; it is important that any faulty springs are immediately replaced. The adjustment of the brake units is external and should be made in the following manner :—

(i.) Jack up the aeroplane wheels, and, working on one wheel at a time, remove the pin engaging the piston of the operating mechanism to the external cam lever.

(ii.) Lift the cam lever until the shoes are lightly touching the brake drums. With the cam lever in this position, adjust the connecting link to engage with the lever and insert the pin.

(iii.) Apply the initial pressure of 400–450 lbs. per sq. in. to the system and note the position of the piston (the wheels should now have a slight braking effort on them).

(iv.) Reduce the pressure to zero and measure the downward travel of the piston. This should be from 0·2 in. to 0·25 in. Should the travel be incorrect, adjust the connecting link until the correct travel is obtained.

(v.) After adjusting all brake units as explained above, it is important to ascertain that the wheels are quite free to rotate when the pressure in the system is reduced to zero.

Liquid used

During normal service only the correct liquid advised by the manufacturer should be employed in this system. In emergency, however, an equal quantity of pure castor oil and methylated spirits (well mixed) may be used as a substitute for a short period. After using the substitute the system should be drained and filled with the correct liquid at the earliest opportunity.

MAINTENANCE OF THE BRITISH AUTOMATIC PILOT

By Wing-Commander G. W. Williamson, O.B.E., M.C., M.Inst.C.E., M.I.Mech.E., M.I.E.E.

THE principle and mode of functioning of the British automatic pilot are dealt with on p. 369 of Vol. I. The illustrations show various views of the gyros and servomotors; the major proportion of small jobs which make up maintenance is concerned with other parts of the system, but reference will be made where necessary to the illustrations in the previous article.

The system as a whole is shown in the line drawings at Figs. 1 and 2. Fig. 1 shows an air compressor, the oil reservoir and oil separator and piping as far as the test cock; Fig. 2 shows, from the test cock onwards, the pressure gauge, the main control cock, piping ZZ conveying air to the jets which drive the gyros, piping YY to the centralisers of the gyros and thence to main valves and servomotors, and piping XXX to the air expansion chamber and thence to the relay valves; also the course change cock, which in its central position is closed, but which when opened admits air to one side or the other of the piston in the course change cylinder.

The two gyros with their jets and the three servomotors form part of the air system; but in addition there are other components of the automatic pilot which will require maintenance attention: these are connected up by mechanical means such as Bowden cable and include the safety catch lever and the pitch adjusting lever.

The air drier is not shown in Figs. 1 and 2; it is used only infrequently and would be connected after the oil separator and before the test cock; the pressure relief valve is tapped on to the piping next to the pressure gauge.

Compressors

The air supply is obtained from compressors; a single one would be sufficient for two-axes control, but for three-axes systems, with two gyros and three servomotors, two Mark 2 compressors would be necessary or else one of the larger pattern, styled Mark 3. Compressors are mounted on the leading edge of the aeroplane wings as a rule and driven by windmills, as illustrated in Fig. 4 at A. With the increasing speeds of modern aeroplanes, there is an appreciable advantage in eliminating the drag of compressors and windmills; air pressure for automatic pilots installed in future aeroplanes will be obtained from a pressure pump driven from

the main engine in a similar manner to the electric generator, oil pumps and fuel pumps.

Compressors are of the rotary vane type, the external appearance and internal construction being clearly shown in Fig. 3, and diagrammatically at A of Fig. 1. The spindle and its drum are set eccentrically in regard to the chamber; sliding vanes set in slots cut in the drum are pressed in as the gap closes and flung fully out by centrifugal force as the gap opens to its widest half a revolution later. The position of air inlet and outlet to the oil reservoir can be seen in Fig. 1. Fig. 3 shows the outlet junction point, but not the inlet; the junction at the top is that for connection to the base of the oil reservoir.

From Fig. 1 it will be clear that as the compressor draws in air from atmosphere, it exerts also a strong suction on the oil in the reservoir, so that the drum and its vanes are practically flooded with oil. This arrangement has been made for three reasons:

(i.) Ample lubrication obviates mechanical defects in the compressor, which may be running continuously, even though the automatic pilot is not in use.

(ii.) The oil forms a seal at the extremities of the blades or vanes, making the compressor more efficient.

(iii.) The compressed air, in its passage through the piping and mechanism of the automatic pilot, carries with it an oil mist, providing constant lubrication for parts not accessible in flight.

Some aeroplanes are provided with brakes for the compressor spindles, which will prevent the windmills from turning them when the automatic pilot is not in use. The spindle brakes are controlled from the cockpit and their use lengthens the life of vanes and chamber.

The pressure gauge is shown in Fig. 2, and the appearance of the pressure relief valve at K of Fig. 4.

Maintenance of Compressors

As will be seen from A of Fig. 1, also from Fig. 3, there is an oil inlet at the top of the compressor chamber. The quantity of oil is controlled by a jet at that point, protected by a fine gauze filter. This must be inspected and cleaned every ten hours of flying, under normal conditions; but, like any other oil filter, it requires more frequent attention after overhaul or on completion of installation. It should then be inspected and cleaned after the first flight and again after four hours' flying.

Every 120 hours it is usual to examine the compressor casing, as well as all the piping, for leaks or cracks.

Oil Reservoir and Separator

The oil reservoir is shown in diagrammatic form at B of Fig. 1 and the separator at C. Under the same reference letters, their external appearance is shown in Fig. 4. Both figures show the Mark 2 type; Mark 3

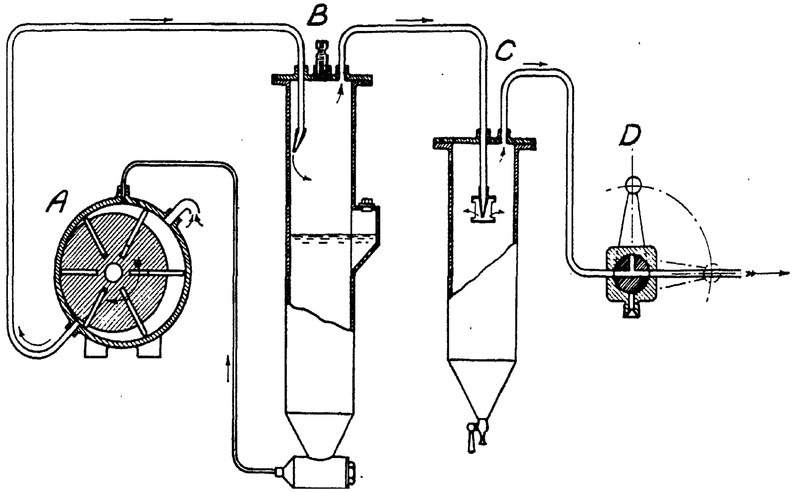


Fig. 1.—AIR COMPRESSOR TO TEST COCK.

combines the two in a single unit, the bottom portion being the reservoir and the top the separator.

The working is, of course, exactly the same; a rich mixture of oil and compressed air emerges from the compressor and impinges on the side of the reservoir cylinder, causing a partial deposition of the oil borne by the air. A further separation takes place in the separator, where the jet impinges on a small plate set in the centre of the cylinder.

Oil is replenished by means of the filler cap shown in Figs. 1 and 4. It must be to the Air Ministry Specification D.T.D. 44 B; it is obtainable from the Vacuum Oil Company Limited. In the Mark 2 reservoir the oil is filled up to the level of the filler cap; in the Mark 3 combined reservoir and separator up to the 1 pint level shown on a gauge on the side.

Mark 2 requires topping up every ten hours of flying and Mark 3 every eight hours.

There is a drain cock at the bottom of the Mark 2 separator and one on the side of the Mark 3 unit. Oil collecting in the separator should be drained daily. It is very important that the drain cock should be closed afterwards.

Oil Filters

While dealing with this unit, it is convenient to list the oil filters, all of which should be removed and cleaned every forty hours of flying. When this is done with the filter at the bottom of the oil reservoir, the reservoir must be filled up with fresh oil to the correct level.

The complete list of filters is as follows :—

(i.) At bottom of oil reservoir, one.
(ii.) In pipes to spinning jets, two.
(iii.) In pipes to centralisers, two.
(iv.) Top of expansion chamber, one.
(v.) In pipes to relay valves, two.

Air Drier

As stated previously, the air drier is not always fitted and is not shown in diagrams or figures. The air, which has been compressed in the compressor, is heated in the process and will take up an increased moisture content. In operating the servomotors, in driving the gyros or even in the expansion chamber, the expansion which takes place results in a fall of temperature and a deposition of moisture. If the outside atmosphere is moist, that deposition may be sufficient to clog the pipes, especially if the temperature is at the same time low ; the temperature of the expanded air may be lower than that of the outside atmosphere and result in freezing in the pipes.

A drier becomes advisable, therefore, in moist atmospheres or in cold weather ; it is a necessity when both conditions obtain, as in winter in the United Kingdom.

The air drier is a cylindrical container, fitted inside with a container of approximately the same size and shape, made of bakelised paper. This is filled with pieces of dry anhydrous calcium chloride ; the compressed air enters the lower part, passes upwards through the drying medium, losing practically all its moisture content in the process, and passes out by an orifice near the top. The used chloride forms a sludge which falls to the bottom ; any violent manœuvre of the aeroplane may project some of this sludge into the air outlet if the sludge level is sufficiently high, as after many hours' flight in bad weather. This may result in clogging of the pipes and jets to an extent which would necessitate the return of the apparatus to the makers.

Frequent removal of the sludge is therefore a necessity. The container holds enough chloride for ten hours in a saturated atmosphere. At least every ten hours' flying the drier should be removed, thoroughly cleaned out with hot water and replaced.

The drier should not, as a rule, be fitted until freezing troubles have actually been experienced.

Test Cock

The test cock is shown at the right of Fig. 1 and at the left of Fig. 2. Its general appearance is indicated at D of Fig. 4. It has two positions, marked *test* and *flying* respectively. Except when actually being used for supply air from an outside source for ground testing, the cock should always be at *flying*. In this position it provides a clear run from the separator or air drier to the main control cock.

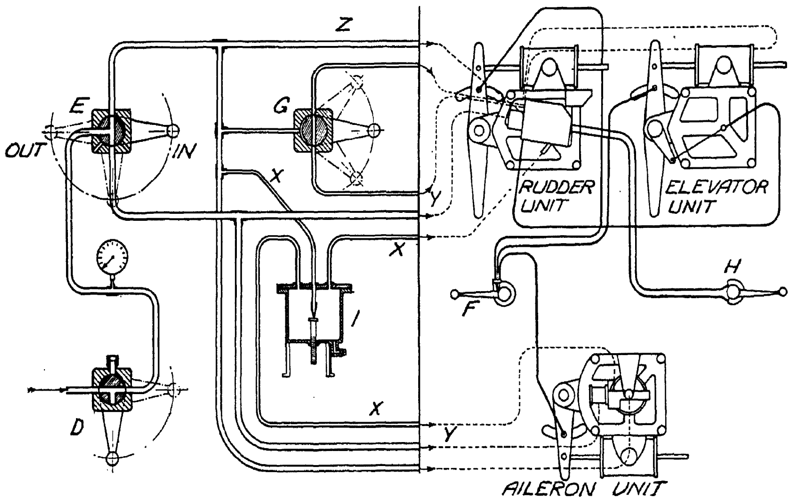


Fig. 2.—FROM TEST COCK TO GYROS AND SERVOMOTORS.

Ground Testing

When used for ground testing, the test cock is placed at *test*. The portable compressors in use supply at least 4 cu. ft. of free air per minute, compressed to a minimum of 35 lbs. per sq. in. The gyros are run up for five minutes by turning the main control to *spin gyro ;* then, with controls set for straight and level flight, the main control cock may be turned to *in*.

Pressure gauge readings should be noted. The pressure must not be less than 35 lbs. before moving the main control cock. A fall of more than 2 or 3 lbs. on moving to *in* would indicate leaks in pipes or joints. A kick or jerk of the control column, at the moment of turning the main control cock to *in*, indicates that the follow-up cables require adjustment, the valve piston not being quite central in its casing. The elevator follow-up cable is shown at U of Fig. 2 on p. 371 of Vol. I.

The aileron gyroscope may be gently tilted or precessed by hand, to check that the servomotor piston returns to the same place for displacements in either direction. At the same time, the correct connection of the aileron cables should be checked by noting that the aileron droops on the side towards which the weight A, Fig. 3 on p. 372 of Vol. I, is tilted. When the aileron control has returned to its central position, the droop of both ailerons should be noticed, to check that it is equal in both ; if not, the cables must be adjusted to give this result.

The course change cock and the pitch lever, dealt with below, should then both be tested in turn to see that the control surfaces concerned function satisfactorily.

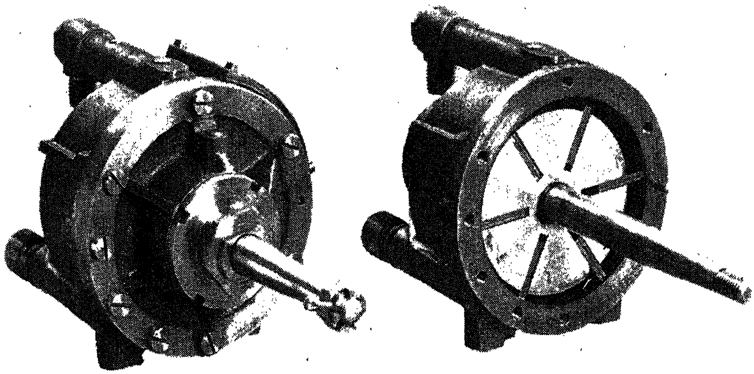


Fig. 3.—COMPRESSORS.

As the aeroplane is not responding to the movements of the gyros and the follow-up movements are not, therefore, in normal operation, it is essential that the movement of the servomotor pistons should be slight; that is, under no circumstances should they be allowed to reach the end of their travel.

Main Control Cock

This is illustrated at E of Fig. 4 and its connections shown in Fig. 2. It has three positions, *out*, *spin gyro* and *in*. The full lines in Fig. 2 show the *in* position, in which the air from test cock and pressure gauge can pass both to the gyro jets and along the second set of pipes to centralisers and expansion chamber. The *out* position cuts off the air from all pipes and *spin gyro* allows the air to pass to pipes ZZ only, spinning the gyros without operating, amongst other things, the servomotors.

There is no part of the cock which requires regular maintenance, but the daily inspection must check that the main control cock is at *out* before the aeroplane leaves the ground and during take-off.

Safety Catch or Pins Lever

The dummy rudder bar is connected to the real rudder bar by a removable pin, shown in Fig. 1 on p. 370 of Vol. I. Similar connections link up the gyro control to the elevator K of Fig. 2 on p. 371, and ailerons K of Fig. 4 on p. 373. All three pins can be withdrawn in emergency by movement of the pins lever illustrated at F of Figs. 2 and 4.

The lever is connected to the pins by Bowden cables, which must be so adjusted that when the pins are in there is no appreciable shake, and also that movement of the lever results in complete withdrawal of all

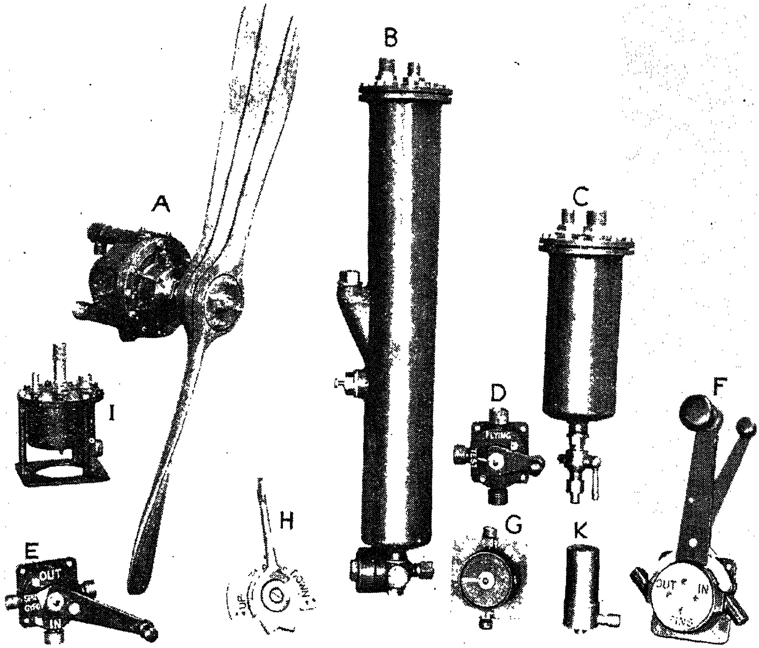


Fig. 4.—SOME COMPONENTS OF THE AUTOMATIC PILOT SYSTEM.

three pins. There should be at least four notches to spare on the pins lever rack, to ensure that no stretching of the cable will result in one or more pins not being fully withdrawn.

On the daily inspection, the pins should be checked to ensure that they engage and disengage freely; when this inspection is completed, the lever must be set to *in* and the control surfaces moved until the pins are all engaged. On the forty-hour inspection, it is usual to check the safety pin mechanism throughout for wear.

Course Change Cock and Pitch Lever

The course change cock is connected into the air system and admits air to one side or the other of a small piston connected by a link and perforated quadrant to the inner gimbal ring B of the rudder gyro (Fig. 1 on p. 370 of Vol. I).

The application to the inner gimbal ring of the torque resulting from the movement of the piston causes the rudder gyroscope to precess in azimuth, with a consequent change of course at the rate of 90 degrees per minute. A complete circle would take four minutes if the course

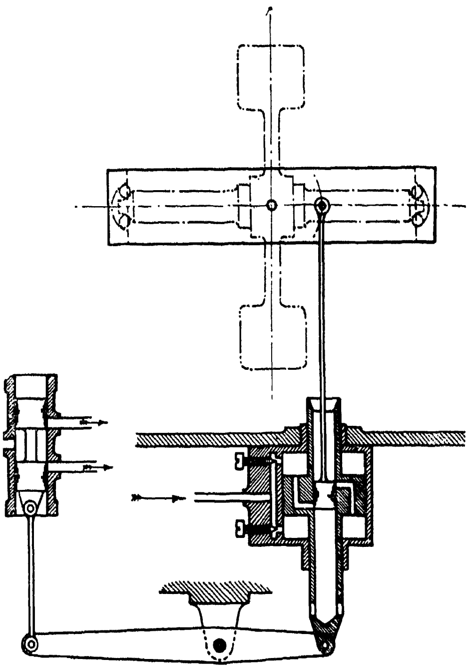


Fig. 5.—DIAGRAM OF RELAY VALVE.

change cock is allowed to remain so long either at *port* or *stb'd.* The cock is shown at G of Figs. 2 and 4.

The pitch control lever, shown at H of the same two figures, enables the pilot to adjust his climb or dive within small limits. Through Bowden cables the lever is connected to a small spring controlling the movement of the elevator gyro outer gimbal ring.

At the daily inspection, the course change cock should be set for straight flight and the pitch adjusting lever for level flight. Little maintenance is required, except to see that both units work freely. After installation or overhaul, both can be checked for functioning, to see that the control surfaces move in the right direction when the cock or lever is set for that attitude.

Relay Valves and Air Expansion Chamber

In a previous article the functioning of the gyro, rudder valve and rudder servomotor has been described. The elevator and aileron servomotors are not operated by their gyros directly through single valves, but through a relay valve operating a secondary valve, which in turn operates the servomotor.

The working of the relay valve is shown in Fig. 5, which is not to scale, but purely diagrammatic. The gyro rotor and its inner gimbal ring are shown at the top, with a link which is, in effect, the piston rod of the inner piston of the relay valve. The inner piston moves up or down within a second piston and thus admits air, by means of the two right-angled channels in the outer piston, to the top or bottom half of the cylinder. Admission to the upper half of the cylinder of the relay valve will move the outer piston downwards and a rocking lever transfers this to the piston of the main elevator valve at the left side, which then moves upwards. That upward movement uncovers one of the two ports

admitting air to one side or the other of the servomotor piston, not shown in this diagram.

The relay valves require reduced air pressure and this is supplied to them through the air expansion chamber, illustrated at I of Figs. 2 and 4. It allows some of the air to expand through a jet shown in Fig. 4, the jet being protected by a fine gauze filter which must be inspected and cleaned as stated above under the heading of Filters.

The valves themselves should be cleaned out every forty hours of flying by being flushed with petrol; they are then freshly oiled with clean D.T.D. 44 B oil. The rocking levers may be gently moved to facilitate this process.

Care of Gyro Mechanism

It will be noticed that practically all the maintenance detailed above applies to the accessories rather than to the gyro mechanism itself. Daily, it is permissible to displace very gently the relay valve pistons, to make sure that they move freely, and the travel of the servomotors must be checked to see that in each case it is less than that of the aeroplane controls.

At forty-hour inspections the servomotor packing glands should be inspected; they should be slightly more than finger tight. The following parts should be oiled: bearings of rotors and gimbals and all link bearings, servomotor trunnions, follow-up frame bearings, follow-up ratio pins.

At forty hours also, all pipe unions should be checked for tightness; the rotors should be inspected for free running and to see that the balance nuts are tight, and the gimbal rings should be free on their bearings. This type of inspection can well be carried out in conjunction with lubrication work outlined in the previous paragraph.

Finally, the gyroscopic mechanism should never be dismantled except by the makers or by a specially constituted unit authorised by the Air Ministry to carry out this work. Any interference with the exact adjustment and balancing of the gyro and its gimbal rings and balance weights will impair the usefulness of the equipment.

AERO ENGINE FAULT-FINDING TABLE

By Wing-Commander F. A. Norton, M.Sc., M.I.Mech.E., M.I.Ae.E.

INTRODUCTION

In presenting a general aero engine fault-finding table as much classification and co-ordination as is possible has been made.

In view of the many types of aero engine now in service, it will be appreciated that under "Remedy" only indications can be given in general. Precise detail must be obtained from the makers' instructions according to type.

This table is designed to cover both "air-" and "liquid-" cooled aero engines appertaining to orthodox design.

AERO ENGINE FAULT-FINDING TABLE

1. Difficulty in Cold Starting

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
(a) Popping in carburetter (*ignition being in order*).	Weak mixture.	Mixture control cock open or leaking.	Ensure good fitting control cock and correct setting.
		Insufficient priming.	Check priming pump and system for correct working. Check fuel reaching manifolds.
		Air leaks in induction system.	Examine manifold for cracks and joints for correct assembly.
		Fuel level too low.	Check level.
		Sticking of float feed mechanism.	Ensure easy working.
		Air locks in fuel pipes; choked jet, pipe or filter; dirt or water in carburetter.	Drain off pipe lines and examine fuel system and determine cause.
		Weak compression.	See *guiding symptom* (c).
		Choked slow-running supply.	Clean slow-running section. Check adjustments.
		Incorrect setting of main jets.	Correct the setting.
		Fuel shortage.	Examine for foreign substance in passages, air locks, fuel tank vent pipes and check the flow.
		Atmospheric temperature very low.	Fill cooling system with hot liquid. This is a convenient preventative if system has been drained *or* Take out one plug from each cylinder, preferably the exhaust side, warm and replace *or* Take out six plugs one from each of alternate cylinders and insert one dessertspoonful of warm engine oil, replacing the plugs as quickly as possible *or* Heat oil in system to approximately 50° C. and circulate.

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
		With gas starter, pressure in bottle insufficient. Blocked pipe line, sticking distributor valves.	Dismantle and clean gas starter system.
(*b*) Carburetter floods; smoke from exhaust pipes (*ignition being in order*).	Rich mixture.	Fuel level too high.	Check level.
		Float needle sticking.	Ease.
		Dirt under float needle.	Clean.
		Punctured float.	Renew.
		Float fouling supercharger casing.	Ease.
		Pressure in system too high.	Adjust relief pressure.
		Excessive priming.	Turn engine backwards if possible, if not forwards with main mixture supply lever in operation, *i.e.*, at gate with fuel off until exhaust is clear.
		Seating between jet assembly and carburetter faulty.	Clean and lap.
		Priming device left in the "on" position.	Move to "closed" position.
		Incorrect jets or jet settings.	Adjust as necessary.
(*c*) Uneven resistance when engine is turned.	Compression weak in one or more cylinders.	Valve or valves stuck open.	Check tappet clearances.
		Distorted valve.	Renew.
		Faulty valve seating.	Recut if possible, if not renew.
		Leaky piston rings.	Examine for extent of wear. Replace if over limits.
		Worn piston.	Renew.
(*d*) Engine does not fire at all (*carburation being in order*).	Ignition. No spark at plugs.	Faulty plugs; condensation or deposits of lead oxide on insulation.	Clean, adjust, test. Renew as necessary.
		Switches defective.	Examine toggles and spring, contact fingers and terminals.
		Current "earthed" by faulty wiring.	Examine for defective insulation.
		Starting magneto contact breaker lever bush seized on pivot; spring broken; platinum-point screw slack; earthing button inside cover spring broken or adrift; insulation of contact screw carrier block defective.	Remove lever, ease bush with special reamer; replace spring; readjust contacts to 0·010-0·012 in. gap; replace cover of spring. Change contact-breaker.
		Winding of armature or coil broken down; internal lead or connection broken; slip ring or H.T. pick-up faulty.	Replace by new magneto.
		(*Coil ignition only.*)	
		Accumulator run down.	Recharge accumulator.

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
(e) Engine kicks but does not pick-up. (*Fires only while hand-starter magneto is working.*)	Ignition.	Main switches defective.	Examine contact mechanism, and for correct "earthing." Check gaps of contact breaker points.
	Strong mixture.	Excessive priming.	Turn engine backwards if possible, if not forwards, with main mixture supply lever in open position, *i.e.*, at gate with fuel off, until exhaust is clear.
	Incorrect butterfly throttle setting.	Open too wide.	Close; $\frac{3}{32}$ in. is generally sufficient.

2. Difficulty in Hot Starting

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
(*f*) Engine kicks but does not pick-up.	Rich mixture.	Excessive priming.	Turn engine backwards if possible, if not forwards with main mixture supply lever in open position, *i.e.*, at gate, with fuel off.
		Fuel condensation.	Turn engine backwards if possible, if not forwards with main mixture supply lever in open position, *i.e.*, at gate.

3. Difficulties in Running

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
(*g*) Irregular firing on certain cylinders.	Ignition.	Faulty plugs. Deposits of lead oxide on insulation.	Clean, adjust, test. Renew as necessary.
		Plugs sooty.	Check correct scavenging of oil in sump.
		Plug electrode gaps too wide or too narrow.	Reset.
		Loose terminals.	Check over and tighten.
		Faulty wiring, insulation broken down.	Test insulation and renew wiring as necessary.
	Carburation.	Internal water leaks, joint ring leaking between cylinder block seating and liner.	Change cylinder block.
(*h*) Irregular firing on all cylinders.	Ignition.	Faulty plugs, deposits of lead oxide on insulation.	Clean, adjust, test. Renew as necessary.
		Plug electrode gaps too wide or too narrow.	Reset.
		Magneto contact breaker gaps wrongly adjusted.	Adjust gaps to correct setting.
		Magneto safety gap set too close.	Adjust to correct setting.
		Faulty L.T. pick-up.	Ensure sound connections.

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
	Carburation.	Mixture control cock open or leaking.	Ensure good fitting control cock and control setting.
		Air leaks in induction system.	Examine manifold for cracks and joints and for correct assembly.
(*i*) Loss of power giving reduced revolutions at full throttle, *i.e.*, gate position (*tachometer being correct*).	Over - heating, carburation.	Rated boost setting too high.	Check setting, piping and gauge.
		Weak mixture :—	
		Mixture-control cock open or leaking.	Ensure good fitting control cock and control setting.
		Fuel level too low.	Check level.
		Incorrect setting of main jets.	Correct the setting.
		Fuel shortage.	Examine for foreign substance in passages, air locks and check flow.
		Fuel pump failure.	Examine and test pump and gland.
		Relief valve not working.	Clean and check relief pressure.
	Over - heating, cooling system.	Insufficient liquid.	Add liquid to correct quantity.
		Foreign substance in system.	Wash out and check flow.
		Internal water leak.	Change cylinder block.
		Leaks, air-locks, air ingress.	Examine system.
	Over - heating, combustion.	Excessive carbonisation.	Decarbonise.
		Detonation.	Check correctness of fuel.
	Over - heating, oil system.	Oil pressure failure :—	
		Oil pipe leakages. Choked filter. Dirt under relief valve.	Flush and check system.
		Bearing failure.	Remove engine.
	Boost control failure.	Aneroid punctured. Seizure of relay piston. Aneroid piston valve loose. Worn pins in linkage.	Dismantle and examine boost control system.
	Ignition.	H.T. cable insulation breaking down.	Test insulation.
		Timing insufficiently advanced.	Check advance and retard setting.
		Plug electrode gaps too large or too small. Magneto contact breaker gaps wrongly adjusted.	Adjust gaps to correct setting.
	Compression.	Valves not closing.	Adjust tappet clearances.
		Pistons and rings worn.	Examine for wear.
	Airscrew.	Wrong type.	Check.
	Boost setting.	Incorrect adjustment of maximum permissible boost.	Check setting and check boost gauge.
(*k*) Excessive vibration.	Engine, irregular firing.	See guiding symptoms (*g*), (*h*), (*i*).	
	Engine too cold.	Cooling liquid temperature too low.	Raise to correct running temperature.
	Engine periods.	Running at crankshaft and reduction gear periods.	Run at other speeds.
	Airscrew.	Airscrew flutter.	Test airscrew for truth and balance.

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
		Loose airscrew boss.	Remove airscrew; look for scoring on shaft. Having replaced airscrew, tighten up securing nut and make sure that locking device is secure.
	Engine mounting.	Loose holding-down bolts or faulty engine mountings.	Examine spring washers; note that bolts are sound. Check any bracing wires.
	Carburation.	Butterfly throttles incorrectly balanced.	Correct setting.

4. Difficulties in Stopping

1. Guiding Symptoms	2. General Cause	3. Defect	4. Remedy
(*l*) Engine fires irregularly after switching off ignition.	Ignition.	Switch, earthing contact partial failure.	Stop on fuel. Trace contacts and make good.
	Overheating.	Combustion chambers overheated generally.	Switch ignition on and run slowly for a short period, then switch off again.
(*m*) Engine fires irregularly after switching off ignition. (*Air - cooled engines only.*)	High temperature of combustion chambers.		Switch on ignition and starve by running out fuel after turning off main cocks.
(*n*) Engine fires irregularly after turning off fuel supply. (*Liquid-cooled engines only.*)	Insufficient fuel supply until starvation is critical.		Turn on main cocks and stop on ignition.
(*o*) Engine continues to fire after switching off, but fires regularly.	Ignition.	Switch, "earthing" contact complete failure.	Stop on fuel, trace contacts and make good.

25/50-HOUR AIRFRAME ROUTINE INSPECTION ON MONOSPAR AEROPLANES

FITTED WITH POBJOY NIAGARA III ENGINE

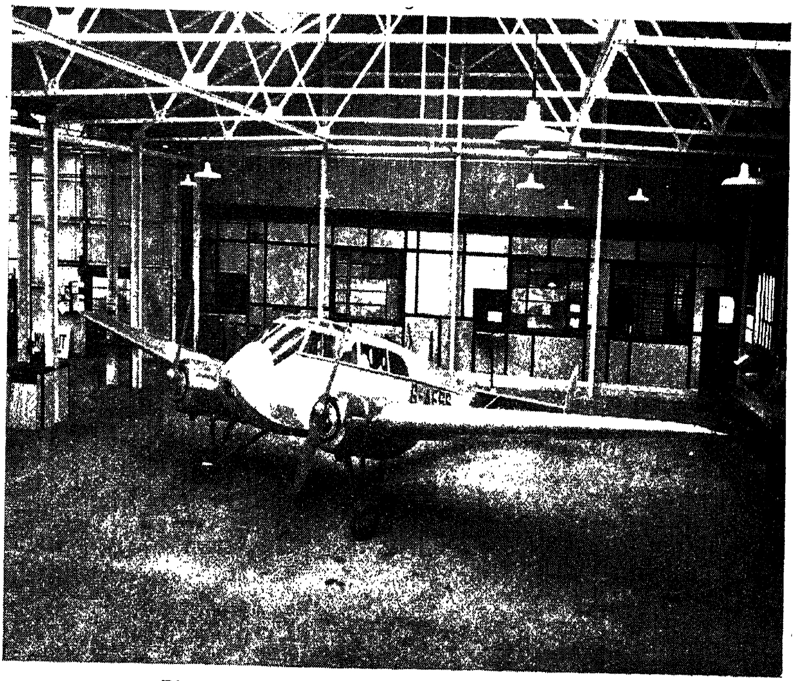


Fig. 1.—General view of Monospar type S.T. 25.

IN the following series of photographs are shown stages in the 25/50-hour airframe routine inspection of Monospar aeroplanes fitted with Pobjoy Niagara III Engine. We are indebted to Messrs. General Aircraft Ltd., London Air Park, Feltham, for facilities for staging these photographs while an actual routine inspection was in progress. The operations shown in Figs. 27–39 are done in the 50-hour inspection only.

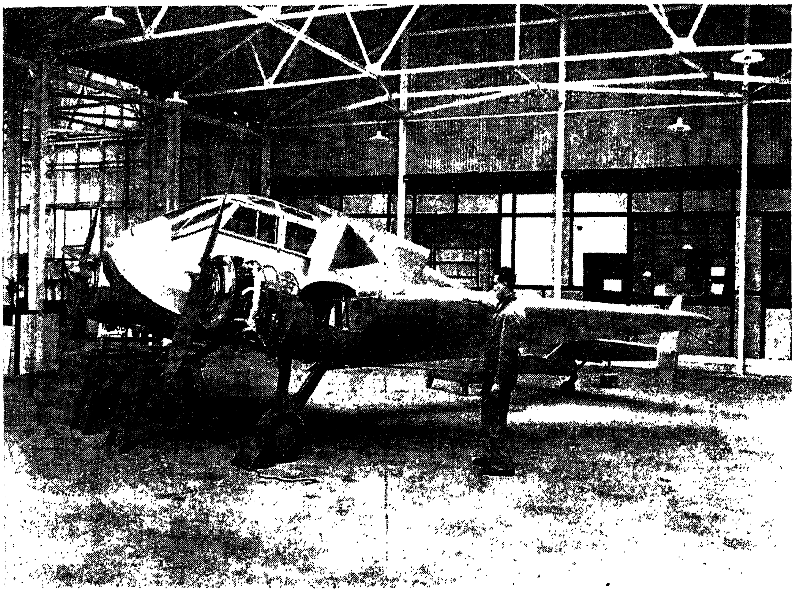


Fig. 2.—PREPARING AIRCRAFT FOR TRESTLING-UP AND INSPECTION.

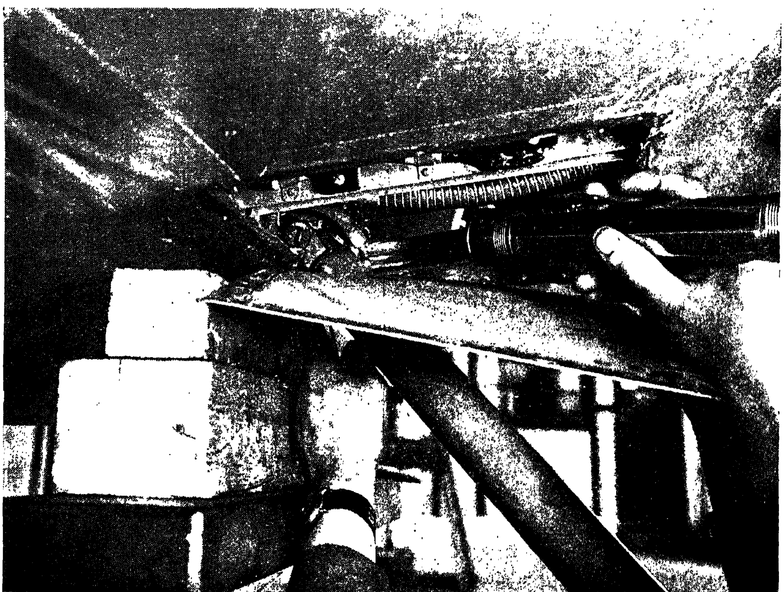


Fig. 3.—INSPECT UNDERCARRIAGE JOINTS AND GENERAL ASSEMBLY
Examining attachment of axle tube to fuselage.

Fig. 4.—INSPECT UNDERCARRIAGE JOINTS AND GENERAL ASSEMBLY (2).
Examining compression leg and axle fittings for wear and condition.

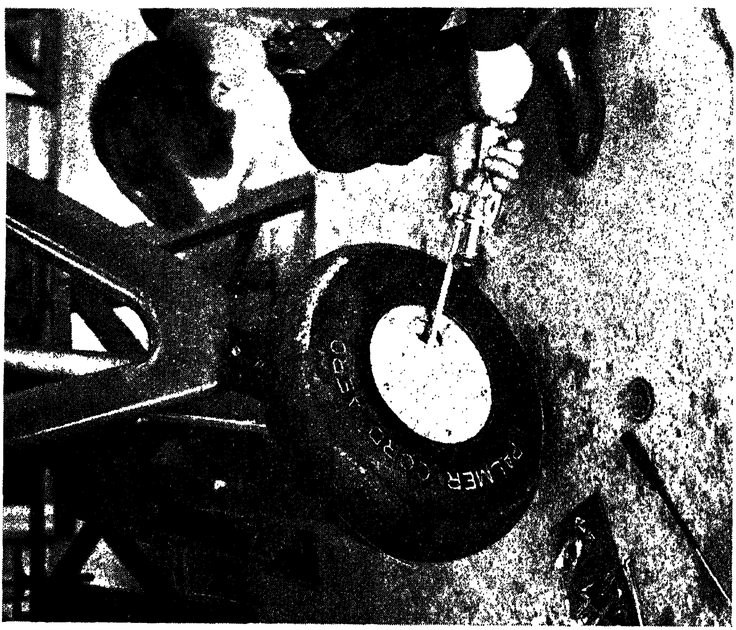


Fig. 5.—INSPECT TYRE PRESSURES.

Main wheel pressure, 30 lbs./sq. in. Tail wheel pressure, 35 lbs./sq. in.

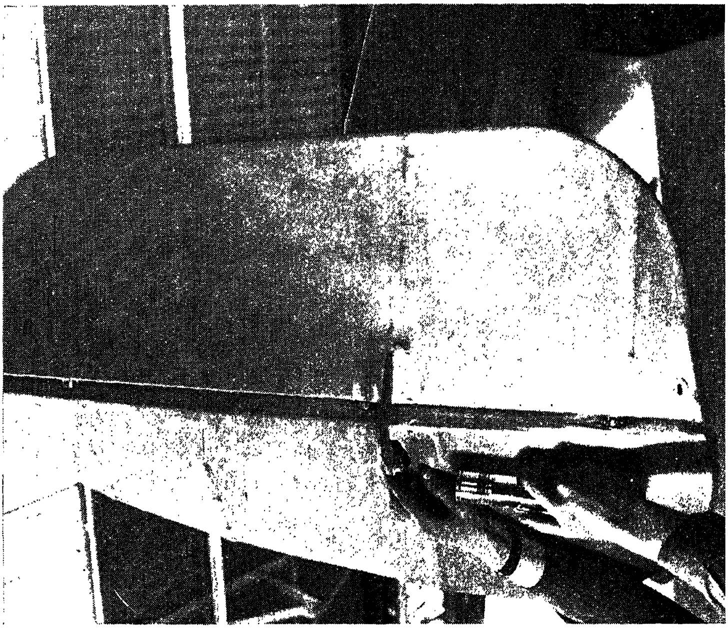


Fig. 6.—INSPECT TAIL UNIT AND TAIL WHEEL (1).

Examining rudder controls.

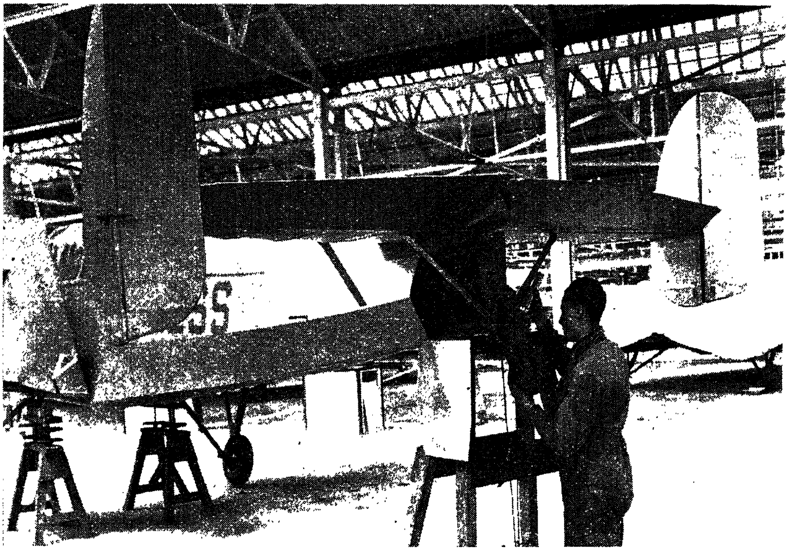


Fig. 7.—INSPECT TAIL UNIT AND TAIL WHEEL (2).
Checking tail wheel mounting for any signs of slackness in bearings, etc.

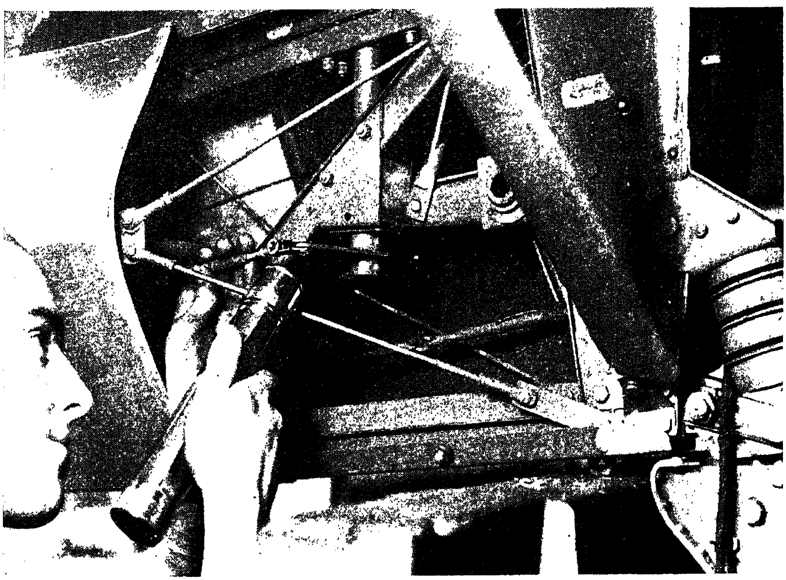


Fig. 8.—INSPECT TAIL UNIT AND TAIL WHEEL (3).
Rudder control cables and pins being checked over.

Fig. 9.—INSPECT C/PLANES AND ENGINE NACELLES AND MOUNTINGS (1).
Examining the inside of the port centre plane with the aid of an electric torch. This is accessible from the rear through a laced panel.

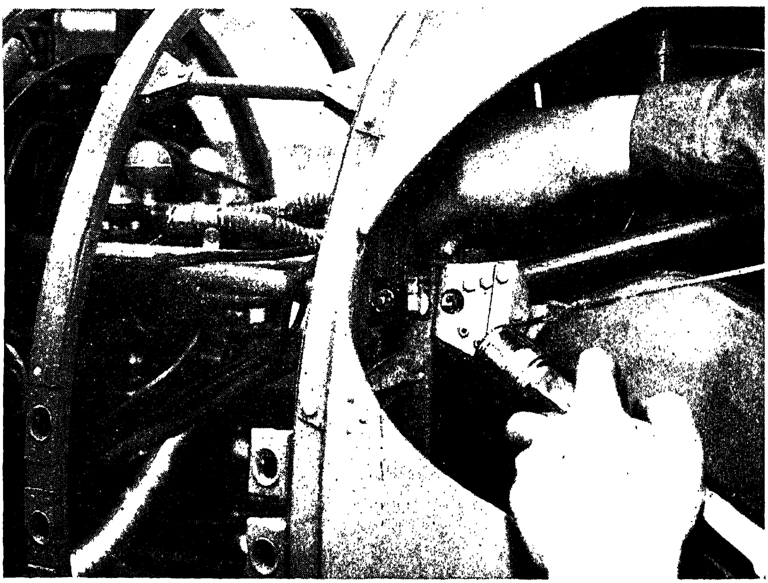


Fig. 10.—INSPECT C/PLANES AND ENGINE NACELLES AND MOUNTINGS (2).
Checking engine bearer attachment bolts for tightness.

Fig. 11 (*right*).—INSPECT C/PLANES AND ENGINE NACELLES AND MOUNTINGS (3).

Checking engine mounting bolts for tightness.

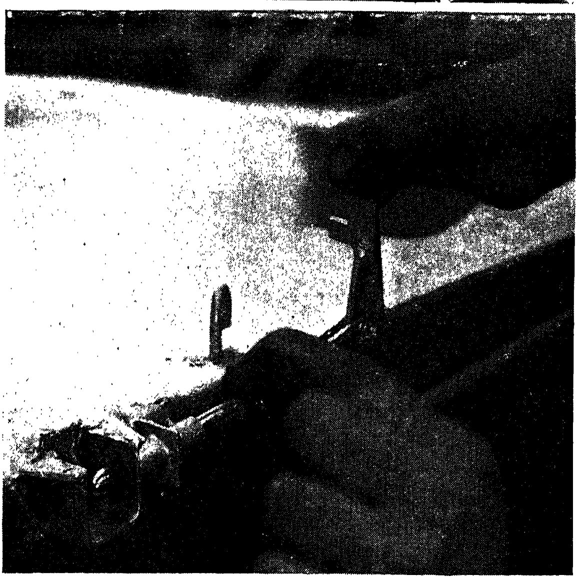


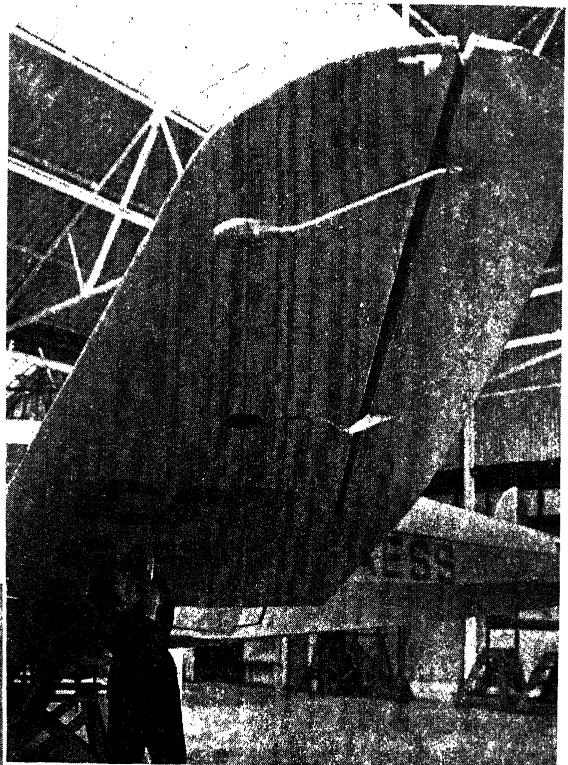
Fig. 12 (*left*). — INSPECTING FOLDING FLAP LOCKING GEAR ON MAIN PLANE FOR CORRECT WORKING AND SIGNS OF WEAR (4).

Fig. 13.—INSPECT C/PLANES AND ENGINE NACELLES AND MOUNTINGS.
Checking over bolts in nacelle for tightness. These are readily got at with the wing folded.

ig. 14.—CHECKING FOLDING FLAP HINGES FOR CONDITION AND WEAR.

Fig. 15 (*right*). INSPECT MAIN PLANES AND FLAPS (1).

Examining aileron controls and wing structure through the inspection doors pro-



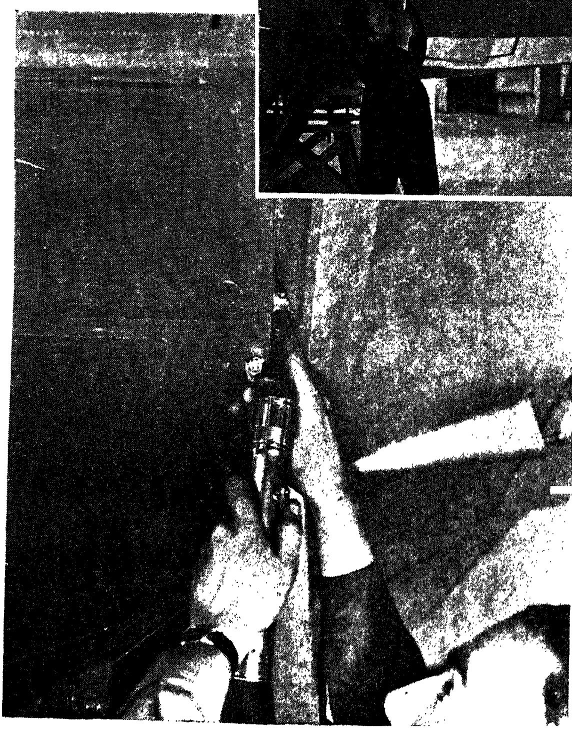


Fig. 16 (*left*).—INSPECT MAIN PLANES AND FLAPS (2).

Checking over aileron hinges for condition.

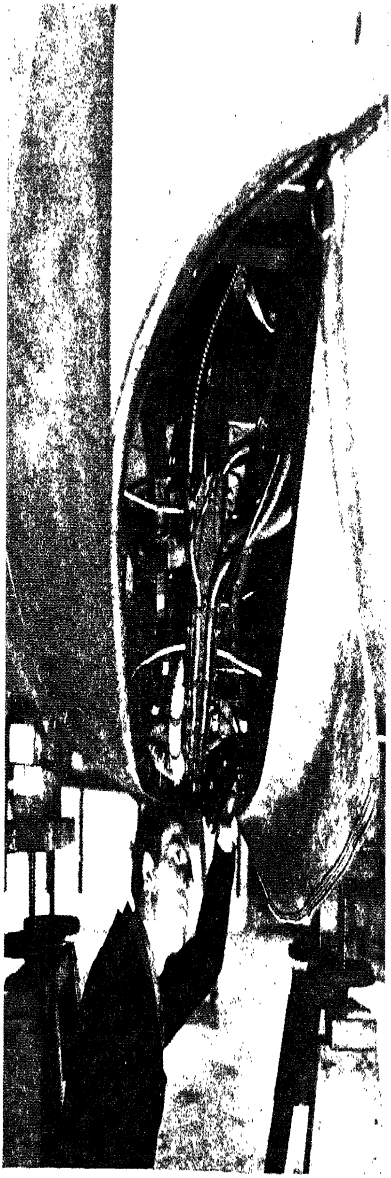


Fig. 17.—Inspect all parts under floor (1); Examining flying controls and pipe lines.

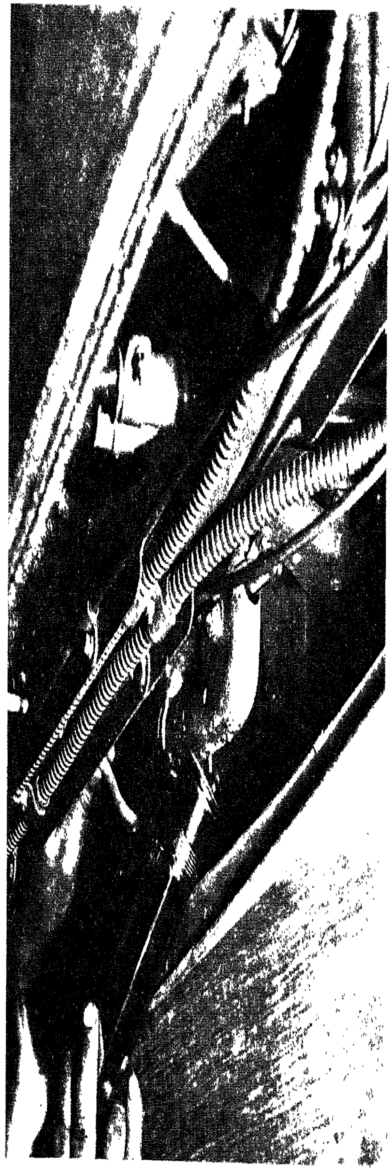


Fig. 18.—Inspect all parts under floor (2). Checking over Palmer brake differential units and pipe lines.

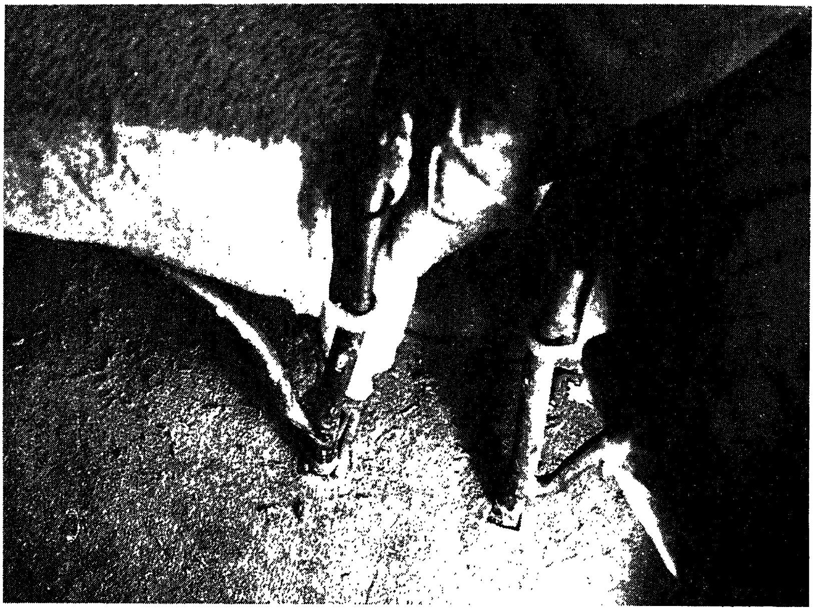


Fig. 19.—INSPECT SAFETY BELTS AND SEATS (1).
Examining seats for condition and security.

Fig. 20.—INSPECT SAFETY BELTS AND SEATS (2).
Checking over safety belts and attachments for condition and security.

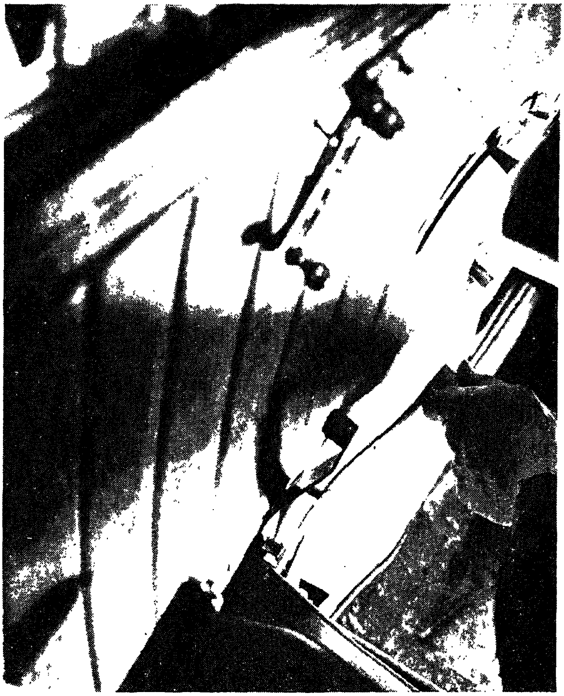


Fig. 21 (*right*).—INSPECT ALL ENGINE CONTROLS (1).

Examining throttle controls in cabin.

Fig. 22 (*left*).—INSPECT ALL ENGINE CONTROLS (2).

Examining throttle controls forward of engine mounting bulkhead.

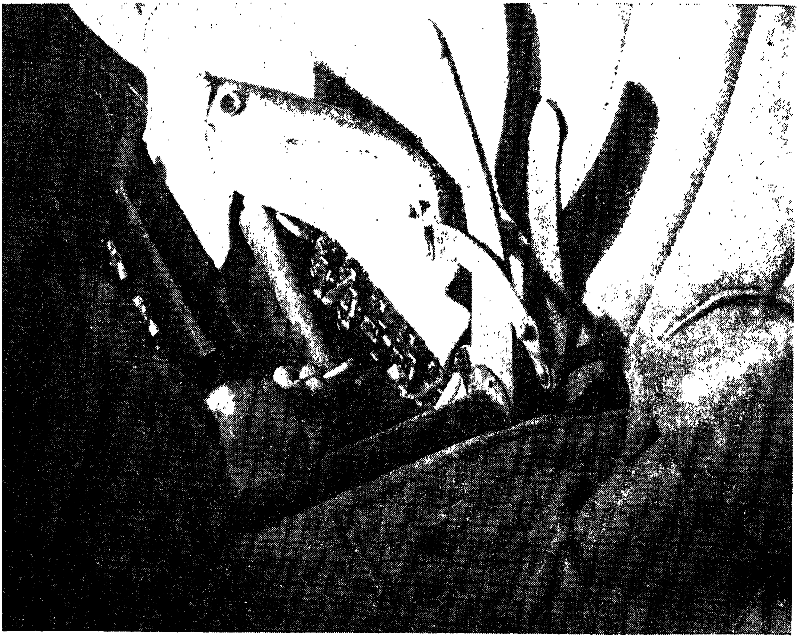


Fig. 23 (*above*).—INSPECT ELECTRICAL EQUIPMENT (1).

Removing and checking fuses.

Fig. 24 (*left*).—INSPECT ELECTRICAL EQUIPMENT (2).

Checking the 12-volt battery with hydrometer.

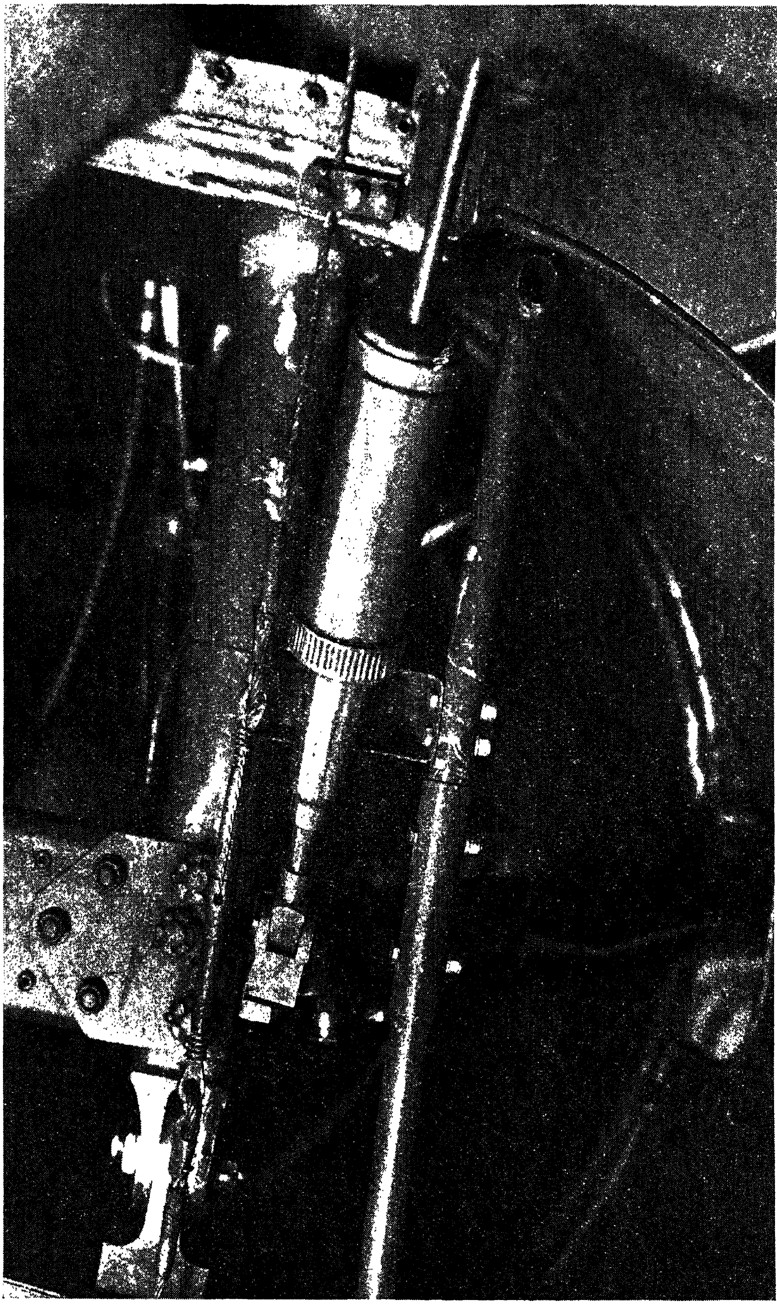


Fig. 25.—LUBRICATE IN ACCORDANCE WITH CHART.
Greasing the universal joint at the upper end of the compression leg

Fig. 26.—INSPECT REAR FUSELAGE STRUCTURE.

Examining with the aid of an electric torch the rear fuselage structure. This is seen by lifting the leather curtain at the rear of the luggage compartment.

Fig. 27.—REMOVE WHEELS, INSPECT HUBS AND BRAKES, AND REPACK HUBS WITH GREASE (1).

The wheel removed, the brake liners are being cleaned with Palmer Brake Block Cleanser.

Fig. 28.—REMOVE WHEELS, INSPECT HUBS AND BRAKES, AND REPACK HUBS WITH GREASE (2).

Checking over the bolts securing the two halves of the wheel hub together.

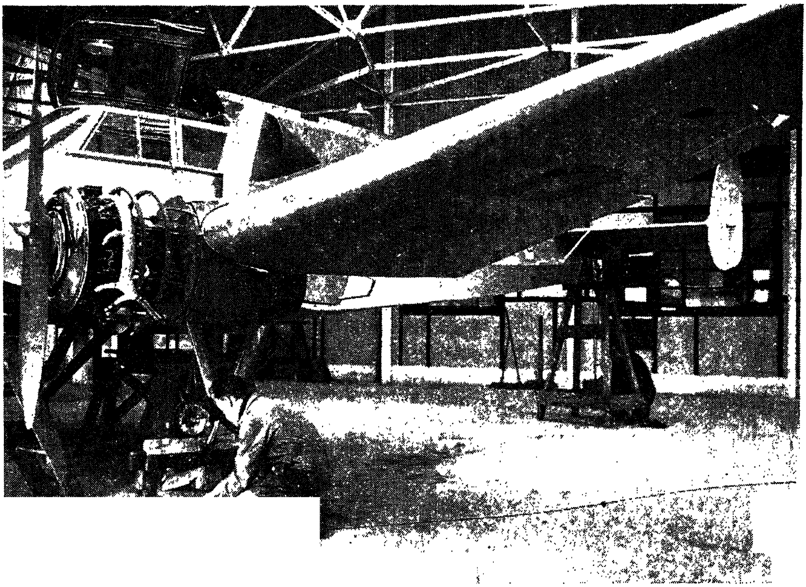


Fig. 29.—CHECK STUB AXLE ALIGNMENT.
This is done with plumb lines and diagonal measurements to the tail.

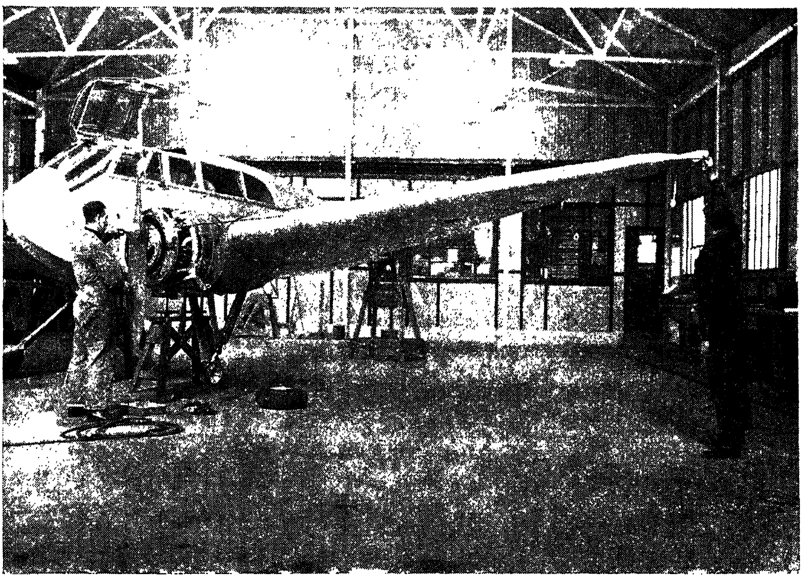


Fig. 30.—CHECK RIGGING DIMENSIONS (1).
Checking the diagonal measurement from centre of engine shaft to wing tip.

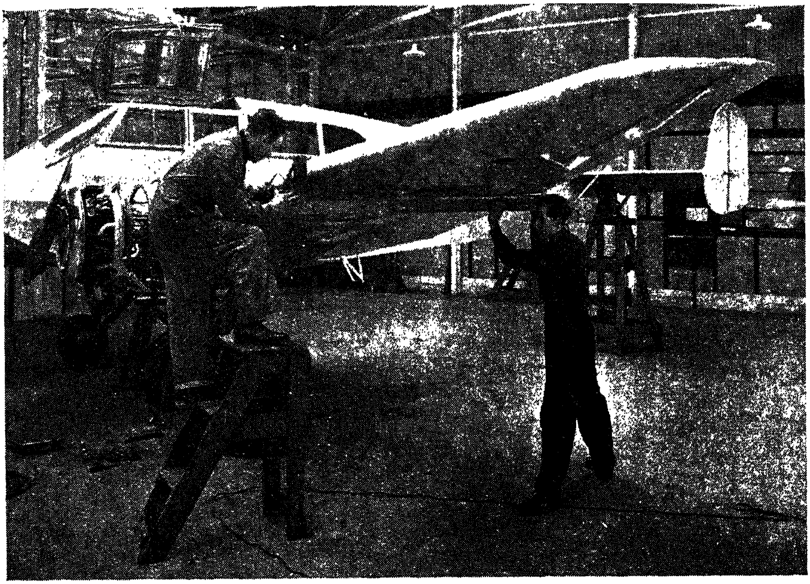


Fig. 31.—CHECK RIGGING DIMENSIONS (2).
Measuring wing incidence with special boards and inclinometer.

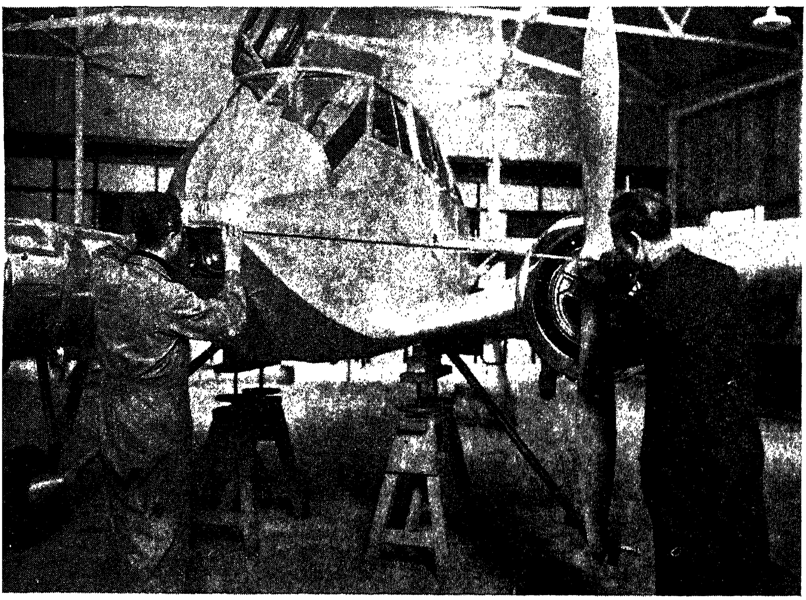


Fig. 32.—CHECK RIGGING DIMENSIONS (3).
Taking diagonal measurements from centre line of engine shaft to centre line of fuselage.

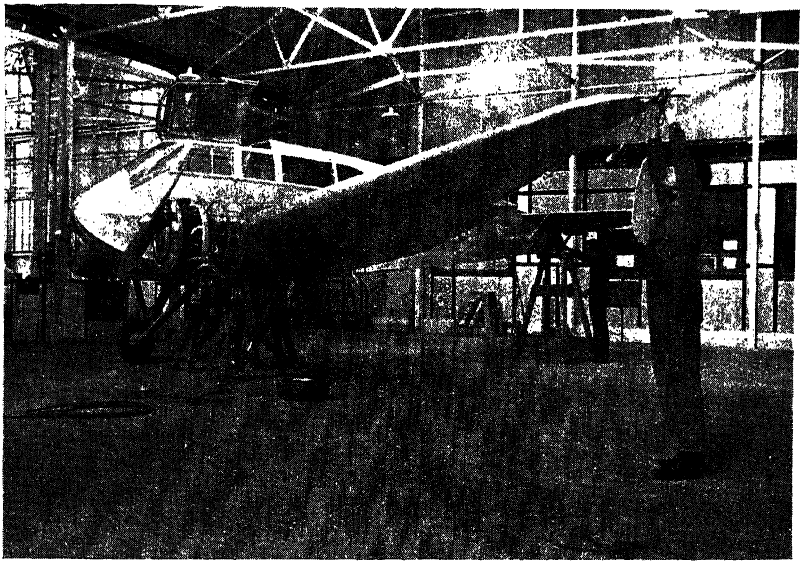


Fig. 33.—CHECK RIGGING DIMENSIONS (4).
Taking diagonal measurements. Wing tip to centre line of rear fuselage.

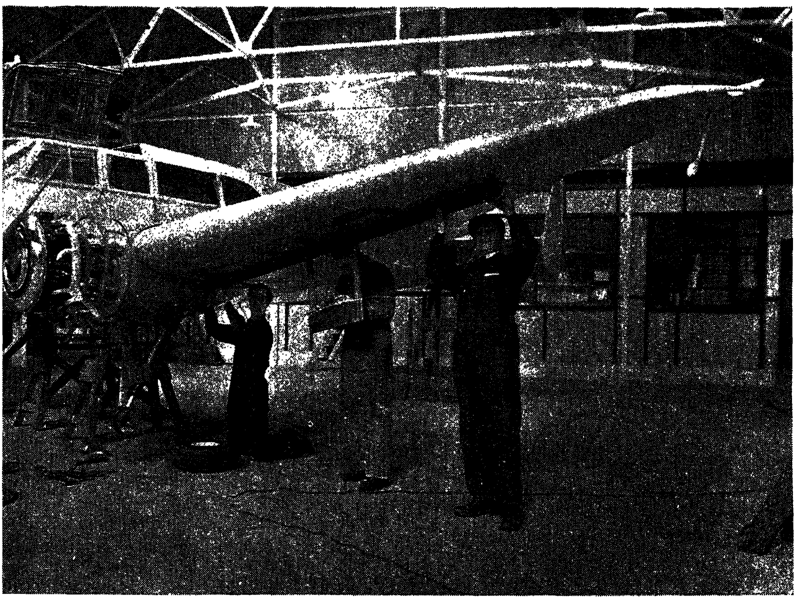
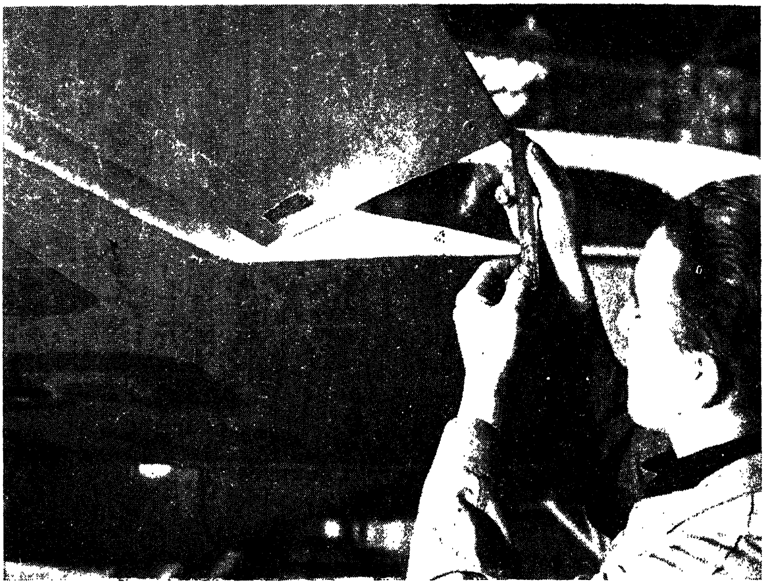


Fig. 34.—CHECK RIGGING DIMENSIONS (5).
Checking dihedral angle of wings.



35.—CHECK MOVEMENT OF ALL CONTROL SURFACES (1).
Measuring upward movement of ailerons.

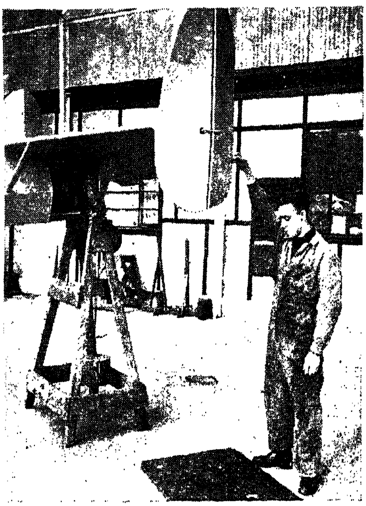


Fig. 36.—CHECK MOVEMENT OF ALL CONTROL SURFACES (2).

Measuring movement of rudders with plumb lines.

Fig. 37.—CHECK MOVEMENT OF ALL CONTROL SURFACES (3).

Measuring upward movement of elevators.

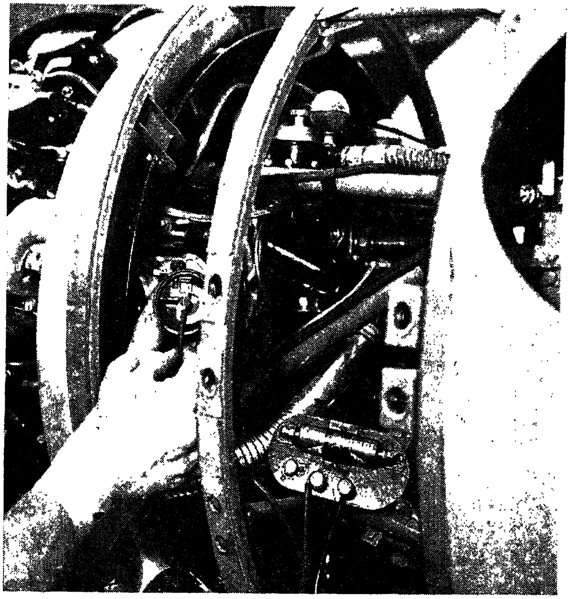


Fig. 38 (*right*).—CHECK IGNITION SYSTEM WITH LAMP AND BATTERY.

Testing continuity of magneto switch-leads.

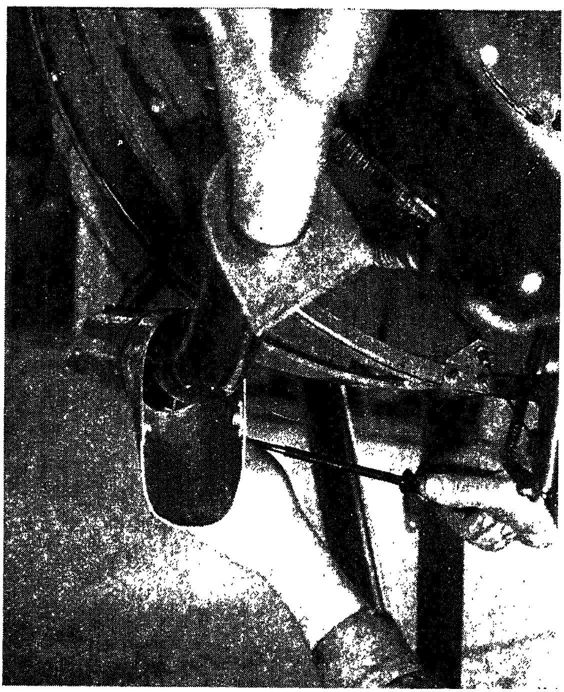


Fig. 39 (*left*).—REMOVE HEATER MUFFS ON EXHAUST PIPES AND INSPECT PIPES.

This is to ensure that no exhaust gas can find its way into the cabin.

25/50-HOUR ENGINE ROUTINE INSPECTION ON MONOSPAR AEROPLANES

FITTED WITH POBJOY NIAGARA III ENGINE

IN the previous section we have dealt with the 25/50-hour routine inspection of the airframe of the Monospar aeroplane. In the following pages we show some of the important stages in the routine inspection of the engine, which is a Pobjoy Niagara III. These photographs were taken while an actual routine inspection was in progress in the works of Messrs. General Aircraft Ltd., London Air Park, Feltham.

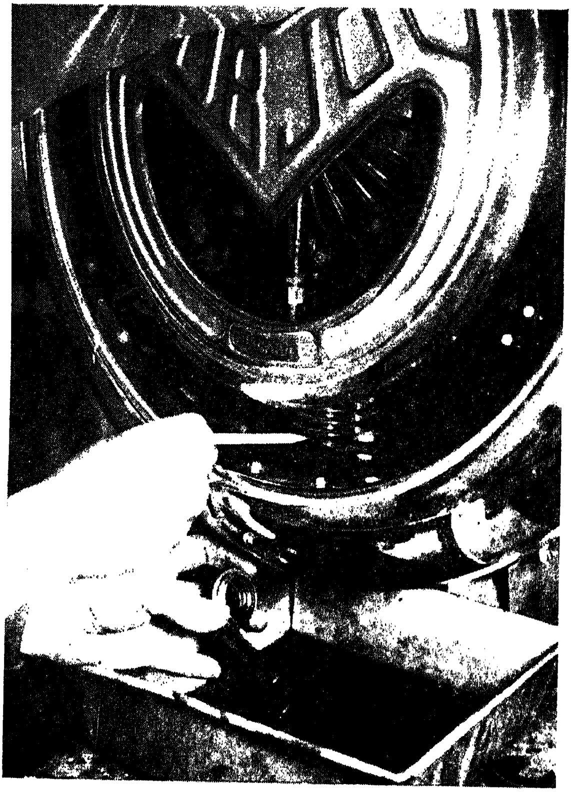


Fig. 1.—CLEAN OIL

Removing the gauze filters from the oil pump.

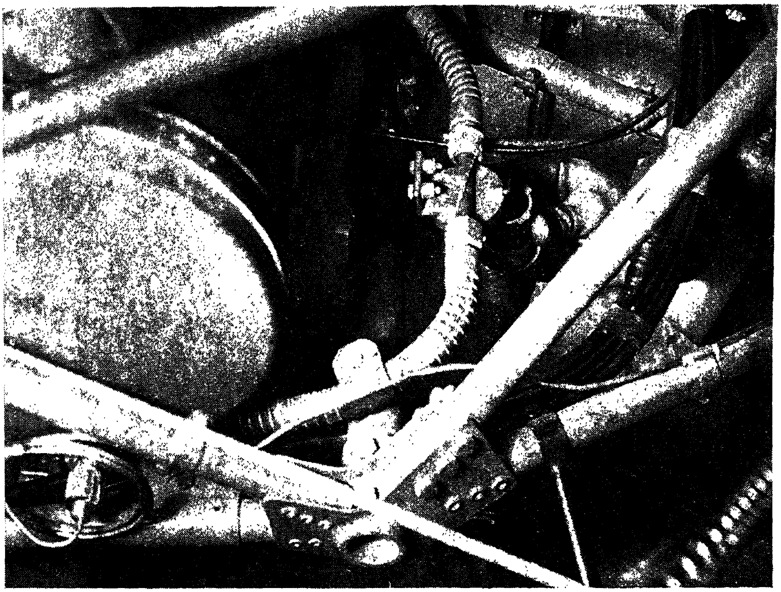


Fig. 2.—CLEAN FUEL FILTERS (1).
Removing main fuel filter in engine nacelle.

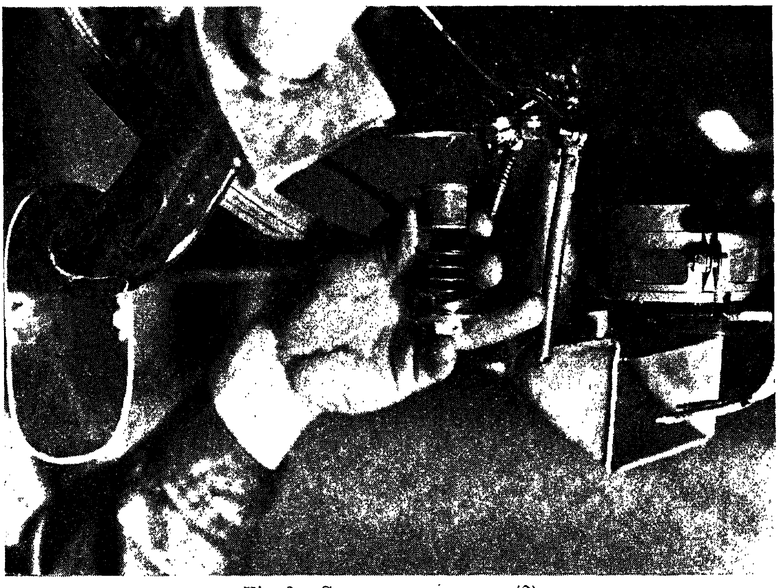


Fig. 3.—CLEAN FUEL FILTERS (2).
Removing fuel filter in body of carburetter.

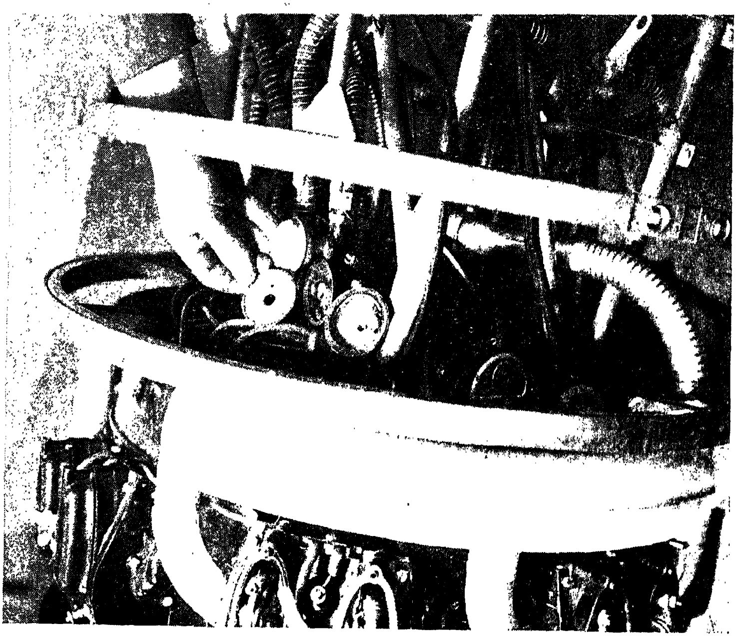


Fig. 4.—CLEAN FUEL FILTERS (3).
Removing fuel filter in fuel pumps.

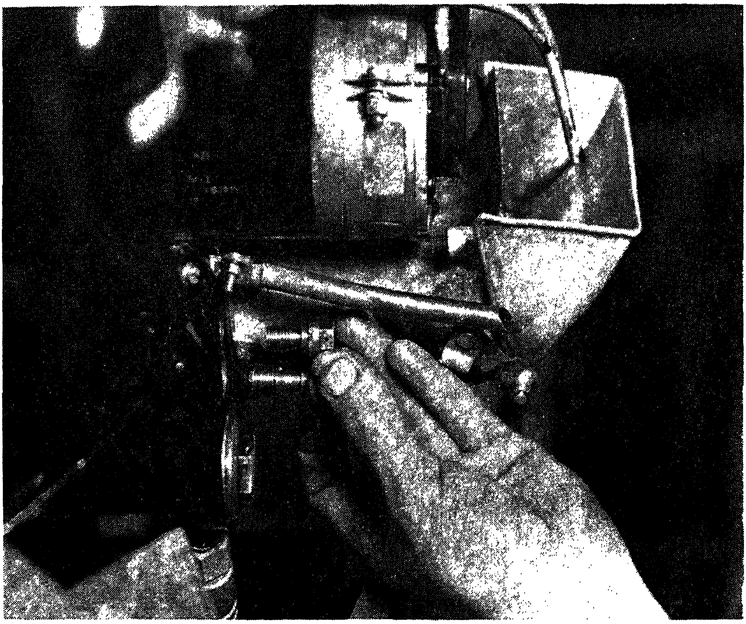


Fig. 5.—REMOVING MAIN AND POWER JETS FROM CARBURETTER *FOR CLEANING.*

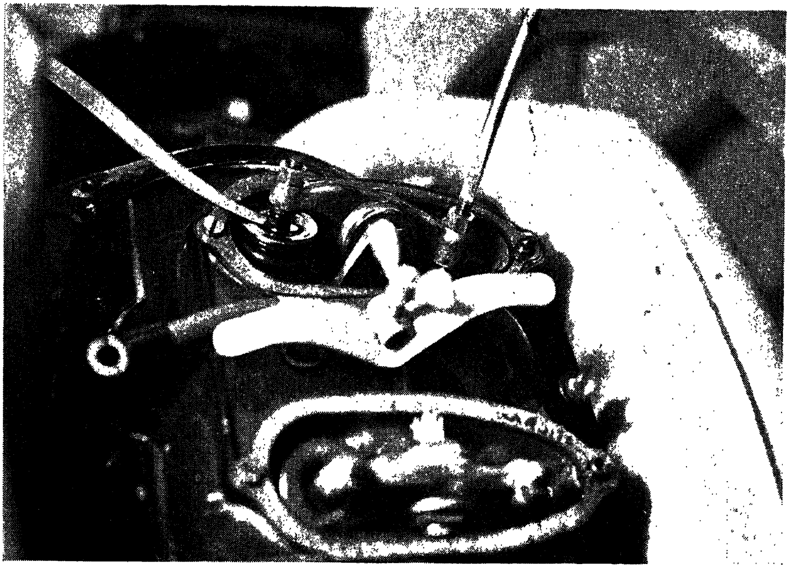


Fig. 6 (*above*).—CHECK TAPPET CLEARANCES AND ADJUST IF REQUIRED.

Adjustment only required if over ·010 in.

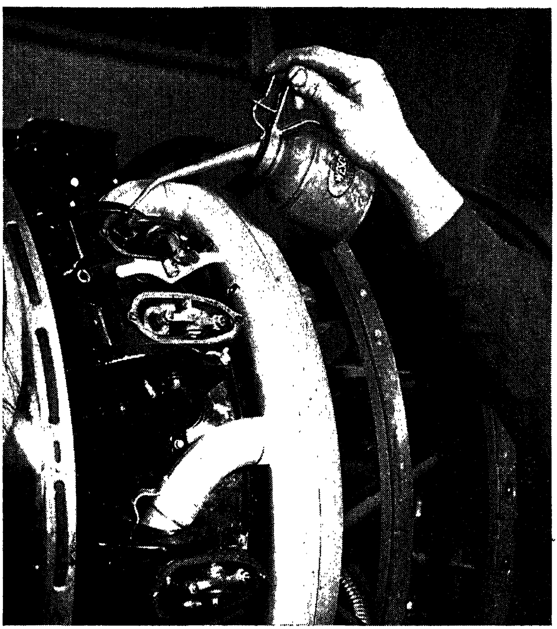


Fig. 7 (*left*).—OIL ROCKERS AND VALVE SPRINGS IF DRY.

This is seldom required as rocker lubrication is very efficient.

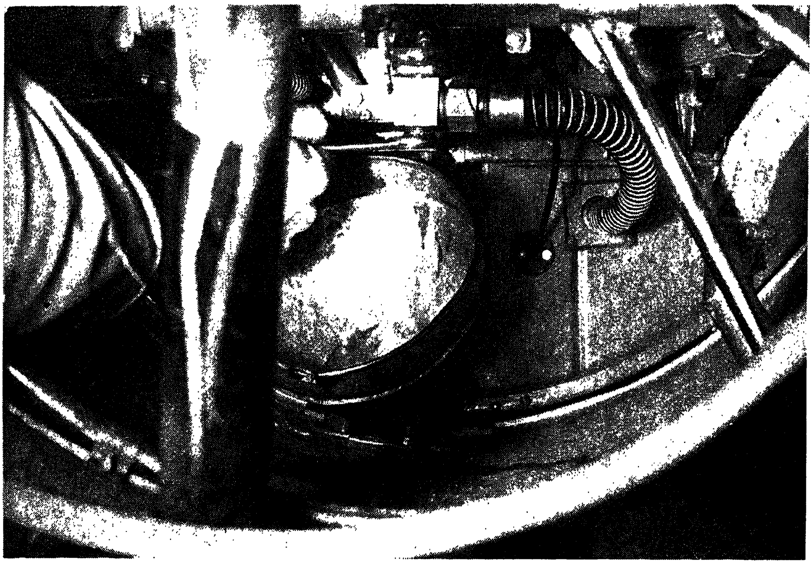


Fig. 8.—DRAIN OIL TANK AND REFILL WITH NEW OIL.
The drain plug is easily accessible with the wing folded.

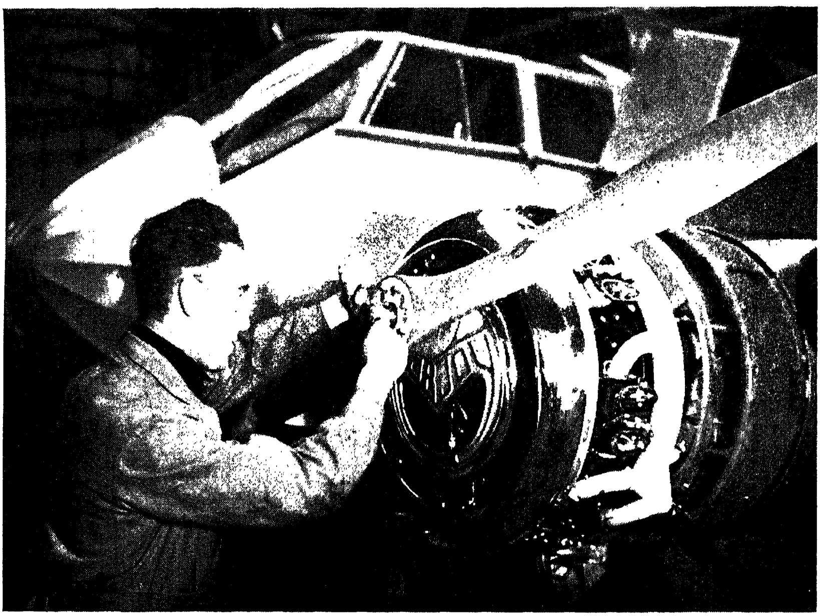


Fig. 9.—CHECK AIRSCREW HUB ON SHAFT FOR TIGHTNESS.
A very important item.

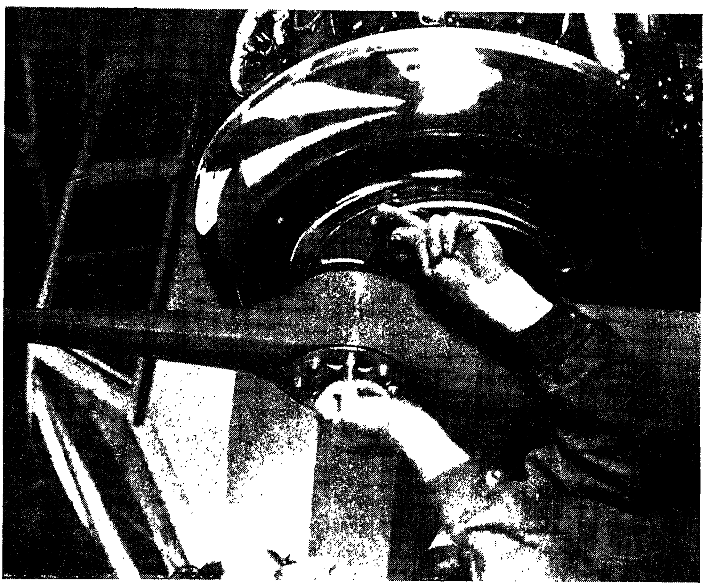


Fig. 10.—CHECK AIRSCREW HUB BOLTS FOR TIGHTNESS.
This should not be overdone as the airscrew is liable to become crushed.

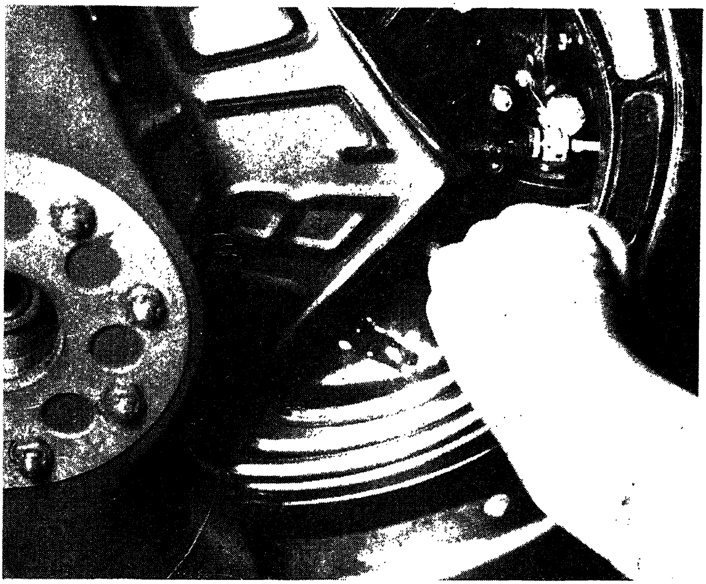


Fig. 11.—CHECK OIL FEED PIPE UNIONS FOR TIGHTNESS.

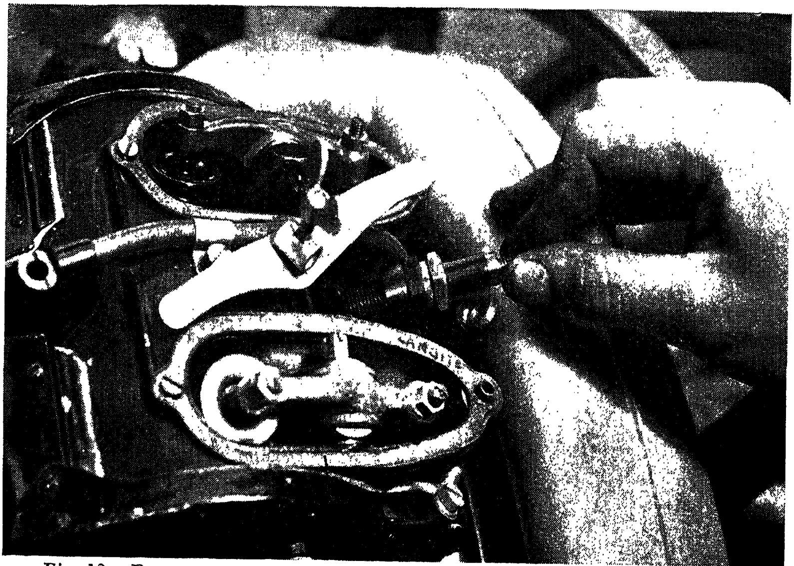


Fig. 12.—REMOVE AND INSPECT PLUGS, DISMANTLE AND CLEAN IF REQUIRED.

Unnecessary dismantling is to be discouraged as the K.L.G. plugs used need very little aintenance.

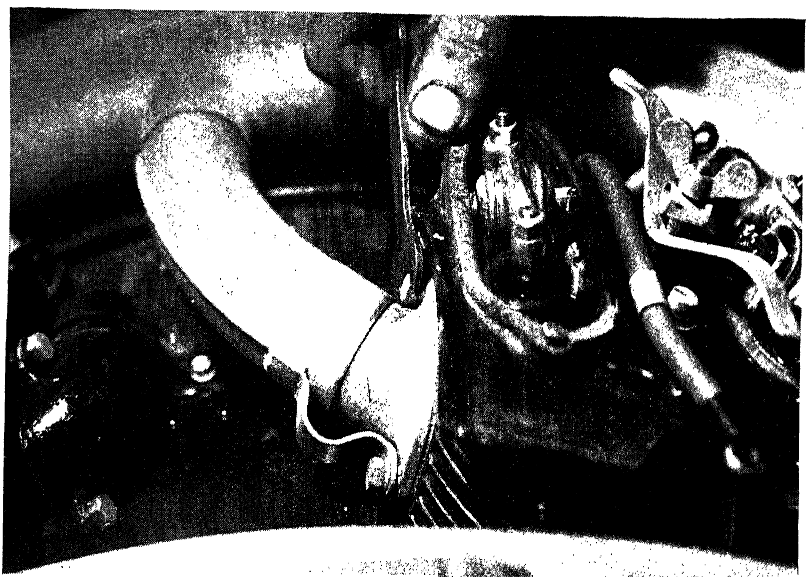


Fig. 13.—CHECK EXHAUST SNOUTS FOR TIGHTNESS

This will in the long nd prevent a lot of wasted ti labour

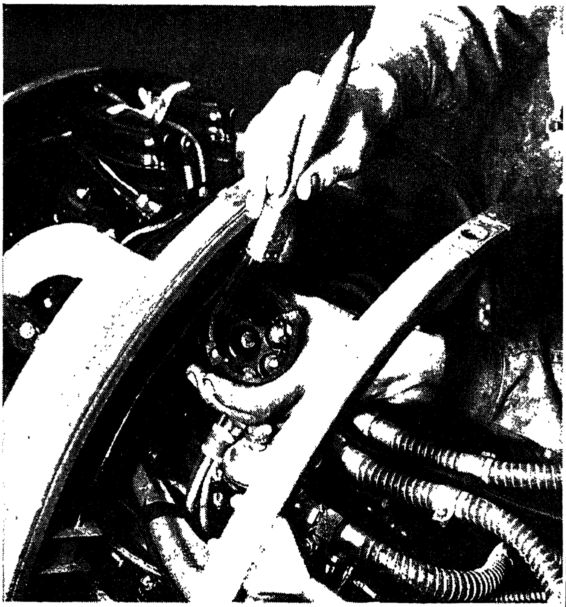


Fig. 14 (*left*).—INSPECT DISTRIBUTORS AND BRUSHES.

A light wash out with petrol is advisable if oil is present on the inside.

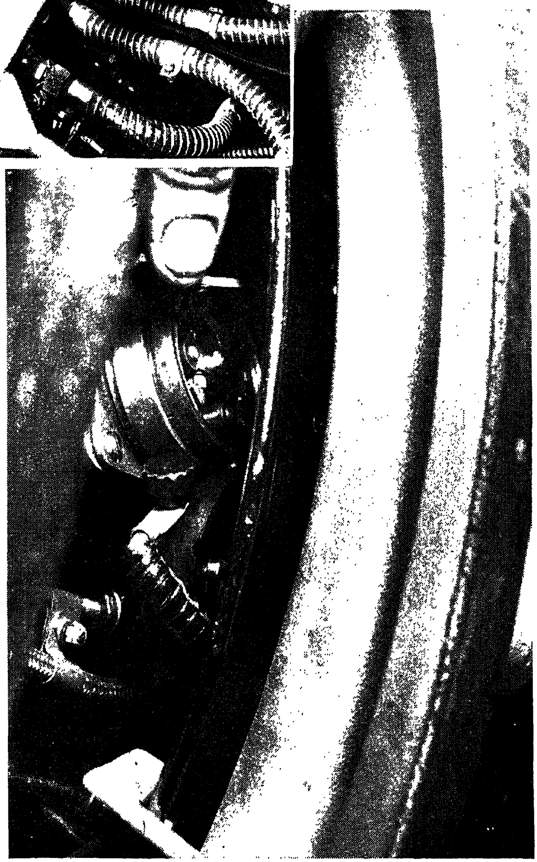


Fig. 15 (*right*).—INSPECT CONTACT BREAKERS AND RESET POINTS IF REQUIRED.

Large gaps sooner or later result in excessive wear and faulty running.

Fig. 16 (*right*).—CHECK AIRSCREW TRACK.

A slightly warped airscrew is often the cause of vibration and bad engine performance.

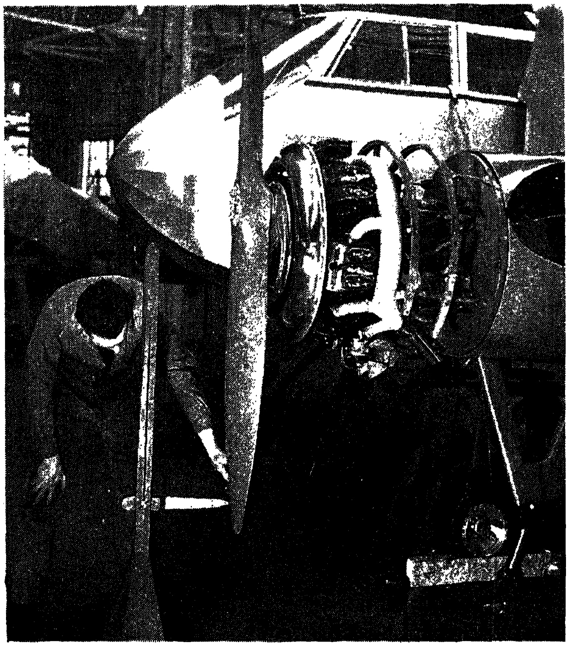
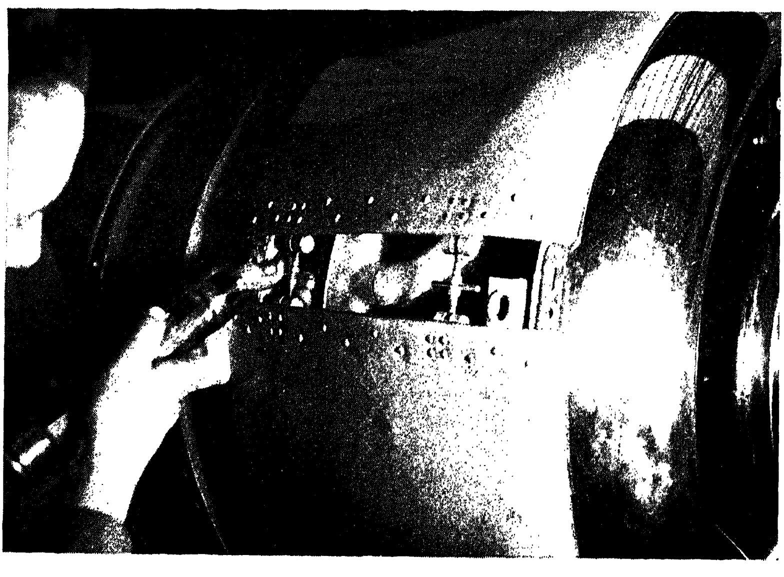


Fig. 17 (*below*).—CHECK COWLINGS AND ATTACHMENTS.

One faulty rivet may lead to considerable damage if not rectified.



KESTREL SERIES V AERO ENGINE COMPLETE OVERHAUL

By Wing-Commander F. A. Norton, M.Sc., M.I.Mech.E., M.I.Ae.E.

Definitions

The Kestrel V aero engine is manufactured by Rolls-Royce Ltd., and is of the " V " type in banks of six cylinders inclined at 60 degrees, geared, composite cooled, fully super-charged and fitted with automatic boost regulator.

The purpose of this section is to describe the operations involved in the complete overhaul of this engine at the end of its stipulated life of 480 flying hours.[1]

This life which may be considered as a maximum is governed by the running and climatic conditions through which the engine has had to work during its life, and may be shortened if its maintenance shows such wear as to make further running inadvisable.

FURTHER LEADING PARTICULARS

Main jet static flow in full strong position .	68 pints per hour
Main jet static flow in full weak position .	22 ,, ,, ,,
Main jet static flow in valve depressed position	100 ,, ,, ,,
Carburetter float chamber fuel lever under 12 ft. head	0·475 in. from joint
Torque at which hand starter clutch should be adjusted to slip	5,000 to 5,300 in./lbs.

LIST OF FITS AND CLEARANCES

It must be understood that the permissible tolerances given must not be exceeded by the limits given for ovality.

The permissible clearances must not be exceeded even though the individual parts may still be within the limits of wear given.

The clearances marked * are adjustable by washers, and are referred to in their corresponding sections of "Inspection and Repair."

[1] Flying hours have been chosen as the basis of maintenance on the assumption storage or rest periods are reasonably short, say not more than 48 hours.

Description.	Dimensions, New.	Permissible Worn Dimensions.	Clearance, New.	Permissible Worn Clearance.
CRANKSHAFT AND BEARINGS	in. mm.	in. mm.	in. mm.	in. mm.
Bore of journal bearing	3·003¼ / 3·003 = 76·283 / 76·276	3·005 = 76·33	·004 / ·004¾ = ·1 / ·12	·006 = ·15
Standard diameter of journal	2·999 / 2·998½ = 76·17 / 76·16	2·957 = 75·11		
Dia. of journal after first re-grind	2·994 / 2·993½ = 76·05 / 76·04	—	—	—
Dia. of journal after second re-grind	2·989 / 2·988½ = 75·92 / 75·91	—	—	—
Dia. of journal after third re-grind	2·984 / 2·983½ = 75·79 / 75·78	—	—	—
Dia. of journal after fourth re-grind	2·979 / 2·978½ = 75·66 / 75·65	—	—	—
Dia. of journal after fifth re-grind	2·974 / 2·973½ = 75·54 / 75·53	—	—	—
Dia. of journal after sixth re-grind	2·969 / 2·968½ = 75·41 / 75·4	—	—	—
Dia. of journal after seventh re-grind	2·964 / 2·963½ = 75·28 / 75·27	—	—	—
Dia. of journal after eighth re-grind	2·959 / 2·958½ = 75·16 / 75·15	—	—	—
Ovality of journals	—	·002 = ·05	—	—
Ovality of crankpins	—	·002 = ·05	—	—
Standard dia. of crankpin	2·499½ / 2·499 = 63·49 / 63·48	2·457 = 62·41	—	—
Dia. of crankpin after first re-grind	2·494½ / 2·494 = 63·36 / 63·34	—	—	—
Dia. of crankpin after second re-grind	2·489½ / 2·489 = 63·23 / 63·22	—	—	—
Dia. of crankpin after third re-grind	2·484½ / 2·484 = 63·11 / 63·09	—	—	—
Dia. of crankpin after fourth re-grind	2·479½ / 2·479 = 62·98 / 62·97	—	—	—
Dia. of crankpin after fifth re-grind	2·474½ / 2·474 = 62·85 / 62·84	—	—	—
Dia. of crankpin after sixth re-grind	2·469½ / 2·469 = 62·72 / 62·71	—	—	—
Dia. of crankpin after seventh re-grind	2·464½ / 2·464 = 62·60 / 62·59	—	—	—
Dia. of crankpin after eighth re-grind	2·459½ / 2·459 = 62·47 / 62·46	—	—	—
Length of crankpin	2·150 / 2·153 = 54·61 / 54·67	2·167 = 55·04	—	—

Description.	Dimensions, New.		Permissible Worn Dimensions.		Clearance, New.		Permissible Worn Clearance.	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.
End float of crankshaft in centre bearing	—		—					
Length of central journal . . .	1·752 / 1·750	= 44·5 / 44·45	1·768	= 44·91	·012 / ·017	= ·30 / ·43	·030	= ·76
Width of centre journal bearing. .	1·738 / 1·735	= 44·15 / 44·07	1·720	= 43·69				
ρLack of truth of centre journal when crankshaft is supported by journals 1 and 7 in V blocks . . .	—		·010	= ·25	—		—	
Lack of parallelism of crankpins with journals, per 1 in. (25·4 mm.) length	—		·001½	= ·04	—		—	
Bore of bush for spring drive in rear end of crankshaft	2·100½ / 2·100	= 53·35 / 53·4	2·103	= 53·42	—		—	
Width of splineways in rear journal before fitting new oversize drive spindle and re-slotting (standard) .	·301 / ·300	= 7·65 / 7·62	·310	= 7·87	—		—	
†Re-slotted—1	·341 / ·340	= 8·66 / 8·64	·350	= 8·89	—		—	
†Re-slotted—2	·361 / ·360	= 9·17 / 9·14	·370	= 9·4	—		—	
†Re-slotted—3 .	·381 / ·380	= 9·68 / 9·65	·390	= 9·91	—		—	
†Re-slotted—4 . . .	·411 / ·410	= 10·44 / 10·41	or·420	= 10·67	—		—	
Bowing of progressive deflection and errors due to ovality to be subtracted.								
CRANKCASE								
Bowing of cylinder face (measured longitudinally)	—		·002	= ·05	—		—	
CYLINDERS, VALVES AND GUIDES								
‡Cylinder bore, standard . . .	5·002 / 5·000	= 127·05 / 127·0	5·005	=127·13	—		—	
Cylinder bore, oversize . .	5·009 / 5·007	= 127·23 / 127·18	5·012	=127·3	—		—	
Ovality of cylinder bore 2 in. (50·8 mm. from top)	—		·006	= ·15	—		—	
Lack of parallelism of cylinder bore .	—		·004	= ·1	—		—	
Length of cylinder liner between spigot faces	7·426 / 7·424	= 188·62 / 188·57	—		—		—	

ρ Total reading on dial indicator = ·020 in.
† Splineways to be re-cut only by engine-maker.
‡ Measured at centre of cylinder. Re-grinding of bore to be carried out only by engine-maker.

Description.	Dimensions, New.	Permissible Worn Dimensions.	Clearance, New.	Permissible Worn Clearance.
	in. mm.	in. mm.	in. mm.	in. mm.
Re-ground of cylinder head joint face in ten stages of ·005 in. (·127 mm.).	—	7·374 =187·3	—	—
Minimum dimension from centre line of exhaust side sparking plug to face for liner joint ring . . .	—	7·374 =187·3	—	—
Longitudinal bowing of cylinder block measured on camshaft bearing faces with straight-edge. . . .	—	·008 = ·2	—	—
Minimum length of thread (depth of cylinder boring for seating of sparking plug adaptor)	—	·325 = 8·25	—	—
Bore of inlet valve guide up to ·500 in. (12·7 mm.) from inner end . .	·405/·404 = 10·28/10·26	·408 = 10·36	·002/·004 = ·05/·1	·006 = ·15
Dia. of inlet valve stem	·402/·401 = 10·21/10·19	·398 = 10·11		
Bore of exhaust valve guide . .	·498/·497 = 12·65/12·62	·501 = 12·73	·004/·005½ = ·1/·14	·008 = ·2
Dia. of exhaust valve stem . .	·493/·492½ = 12·52/12·51	·489 = 12·42		
Ovality of valve stems . . .	—	·002 = ·05	—	—
Ovality of guide bores . . .	—	·002 = ·05	—	—
Dia. of inlet valve seat . . .	1·745/1·740 = 44·32/44·2	1·940 = 49·28	—	—
Dia. of exhaust valve seat. . .	1·680/1·675 = 42·67/42·52	1·860 = 47·24	—	—
Minimum thickness of inlet valve head from lower edge of valve face to bottom of valve head . . .	—	·050 = 1·27	—	—
Minimum thickness of exhaust valve head from lower edge of valve face to bottom of valve head . .	—	·055 = 1·40	—	—
Distance between inlet valve stem face and cotter groove (after re-facing) .	—	·125 = 3·175	—	—
Distance between exhaust valve stem face and cotter groove (after re-facing)	—	·310 = 7·87	—	—
Length of inner valve spring with valve closed	1·471 = 37·36	—	—	—
Load of inner valve spring with valve closed	19 lbs./21 lbs. = 8·62 kg./9·526 kg.	17 lbs. = 7·711 kg.	—	—
Length of outer valve spring with valve closed	1·496 = 38·0	—	—	—
Load of outer valve spring with valve closed	35½ lbs./38½ lbs. = 16·1 kg./17·47 kg.	32 lbs. = 14·51 kg.	—	—
CAMSHAFT AND ROCKER MECHANISM				
Bore of camshaft bearing . . .	·900½/·900 = 22·87/22·86	·903½ = 22·95	·001½/·002½ = ·04/·06	·005 = ·13
Dia. of camshaft journals . . .	·898½/·898 = 22·82/22·81	·895 = 22·73		

Description.	Dimensions, New.	Permissible Worn Dimensions.	Clearance, New.	Permissible Worn Clearance.
	in. mm.	in. mm.	in. mm.	in. mm.
*End float of camshaft	·003/·005 = ·076/·13	·008 = ·20	—	—
Lack of truth of camshaft centre journal when front and rear journals are supported on V blocks . . .	—	·010 = ·25	—	—
Bore of rocker bush	·563½/·562½ = 14·31/14·29	·567 = 14·4	·001½/·003½ = ·04/·09	·006 = ·15
Dia. of rocker shaft	·561/·560 = 14·25/14·22	·556½ = 14·13		
*Total end float of exhaust rockers between each pair of camshaft brackets	—	—	·006/·010 = ·15/·25	·020 = ·51
CAMSHAFT INCLINED DRIVES				
*Backlash between upper driving bevels	—	—	·004/·006 = ·1/·115	·010 = ·25
Bore of housing bush (upper bevel gear)	1·188½/1·187½ = 30·18/30·16	1·190½ = 30·24	·002/·003½ = ·05/·09	·005 = ·13
Dia. of shank on upper drive gear .	1·185½/1·185 = 30·11/30·10	1·182½ = 30·04		
Backlash between top drive serrations and upper bevel gear . . .	—	—	·001/·003 = ·025/·08	·010 = ·25
Backlash between lower drive serrations and lower bevel gear shaft .	—	—	·001/·003 = ·025/·08	·010 = ·25
*Backlash between lower driving bevels	—	—	·002/·006 = ·05/·15	·015 = ·38
Bore of lower bevel gear bush (in housing	·657½/·656½ = 16·69/16·67	·659 = 16·74	·002¼/·003¾ = ·057/·096	·005 = ·13
Dia. of lower bevel gear shaft .	·654/·653½ = 16·61/16·6	·651¼ = 16·54		
GAS DISTRIBUTOR				
Bore of distributor casing bushes .	1·000½/1·000 = 25·41/25·4	1·004 = 25·5	·002/·003 = ·05/·08	·006 = ·15
Dia. of rotor shaft	·998/·997½ = 25·35/25·34	·994 = 25·25		
End float of rotor shaft . . .	—	—	·023/·031 = ·58/·59	·050 = 1·27
Backlash between splines and splineways at each end of coupling . .	—	—	·001/·003 = ·025/·08	·010 = ·25
CONNECTING RODS AND PISTON				
Error of alignment between small and big ends, checked with mandrels.				
Lack of parallelism per 1 in. of mandrel	·000½ = ·013	·002 = ·05	—	—
Twist per 1 in. of mandrel . .	·000½ = ·013	·003 = ·08	—	—
Clearance between bearing black bore and crankpin	—	—	·003¼/·003¾ = ·082/·095	·005 = ·13
Width of bearing block	2·115/2·105 = 53·72/53·47	2·090 = 53·09	—	—

e.—Maximum permissible twist on connecting rod bolt =

Description.	Dimensions, New.		Permissible Worn Dimensions.		Clearance, New.		Permissible Worn Clearance.	
	in.		in.		in.	mm.	in.	mm.
End float of bearing block on crankpin			-		·035/·048	= ·89/1·22	·060	= 1·52
Bore of big end of plain rod . .	3·125½/3·125	79·38/79·375	3·127½					
Outside dia. of bearing block . .			-		·002/·002½	= ·05/·063	·005	= ·13
Ovality of plain rod big end bore .			·003	·08				
Ovality of bearing block bore . .			·002	·05				
Ovality of bearing block outside dia. .			·003	·08				
Width of plain rod big end . .	·749/·747	19·02/18·97	·738	18·75	·003	= ·080	·010	= ·25
Width of track on outside of bearing block	·752	19·1	·759	19·28				
Outside dia. of gudgeon pin floating bush	1·274½	32·373/32·366	1·272½	32·32	·000½/·001¼	= ·013/·032	·002½	= ·06
Bore of connecting rod small end .	1·275½/1·275	32·4/32·38	1·227	32·44				
End float between small end bush and piston faces			- -		·025/·032	= ·63/·81	·070	= 1·78
Dia. of gudgeon pin . . .	1·124½/1·124	28·563/28·56	1·122½	28·51	·000½/·001	= ·013/·028	·002½	= ·06
Bore of gudgeon pin bush .	1·125½/1·125	= 28.59/28·575	1·127	28·63				
Bore of gudgeon pin boss . .	1·125/1·124¾	= 28·575/28·568	1·127	28·63	·000¼/·000 8/10	= ·006/·015	·002½	= ·06
Dia. of gudgeon pin . . .	1·124½/1·124	= 28·563/28·56	1·122½	28·51				
Ovality of gudgeon pin . . .		—	·001	·025				
Dia. of piston at top, measured on axis of gudgeon pin	4·996½/4·964½	= 126·15/126·10						
Dia. of piston at top, measured at right angles to gudgeon pin axis . .	4·970/4·968	= 126·24/126·19						
Dia. of piston at bottom of skirt measured on axis of gudgeon pin .	4·972/4·970	= 126·29/126·24	4·960	= 125·98				
Dia. of piston at bottom measured at right angles to gudgeon pin axis .	4·980/4·978	= 126·49/126·44	4·970	= 126·24				
Clearance between cylinder and top of piston, measured at right angles to gudgeon pin axis					·030/·034		·045	= 1
Clearance between cylinder and bottom of piston skirt, measured at right angles to gudgeon pin . . .					·024	= ·61	·035	= ·89
Width of top ring groove . . .	·096½/·095½	2·43	·100½	= 2·55				
Width of top ring	·085½/·085		·080½	= 2·04			·015	= ·38

Description.	Dimensions, New.	Permissible Worn Dimensions.	Clearance, New.	Permissible Worn Clearance.
	in. mm.	in. mm.	in. mm.	in. mm.
Width of second ring groove . .	·094½ / ·093½ = 2·40 / 2·37	·098½ = 2·5	·008 / ·009½ = ·20 / ·24	·013 = ·28
Width of second ring . . .	·085½ / ·085 = 2·17 / 2·16	·080½ = 2·04		
Width of third ring groove . .	·092½ / ·091½ = 2·39 / 2·32	·096½ = 2·45	·006 / ·007½ = ·15 / ·19	·011 = ·28
Width of third ring	·085½ / ·085 = 2·17 / 2·16	·080½ = 2·04		
Width of fourth ring groove . .	·188 / ·187 = 4·78 / 4·75	·192 = 4·88	·002 / ·003½ = ·05 / ·09	·007 = ·18
Width of fourth ring (drilled scraper)	·185 / ·184½ = 4·7 / 4·69	·180 = 4·57		
Gap of ring when in cylinder . .	—	—	·010 / ·014 = ·25 / ·36	·070 =1·78
Permissible variation in weight of pistons selected for one engine = ½ oz. (14·17 gm.).				
Permissible variation in weight between any two pairs of connecting rods, pistons and pins fitted to one engine = 1 oz. (28·55 gm.).				
WHEELCASE AND DRIVES				
*Backlash between lower camshaft, drive shaft and main drive bevel shaft	—	—	·004 / ·006 = ·1 / ·15	·010 = ·25
Backlash between magneto gear shaft and lower camshaft drive shaft .	—	—	·001 / ·003 = ·025 / ·076	·015 = ·38
End float of magneto gear shaft .	—	—	·002 / ·004 = ·05 / ·10	·020 = ·51
*Backlash between lower vertical drive shaft and main drive bevel gear .	—	—	·004 / ·006 = ·10 / ·15	·010 = ·25
Bore of bush in idler gear . .	·500½ / ·500 = 12·71 / 12·70	·503½ = 12·79	·001½ / ·002½ = ·038 / ·06	·005 = ·13
Dia. of hollow spindle for idler gear .	·498½ / ·498 = 12·66 / 12·65	·495 = 12·57		
Backlash between splines of spring drive spindle and crankshaft . . .	—	—	·000½ / ·001½ = ·013 / ·038	·010 = ·25
Backlash between splines of spring drive spindle and main drive shaft .	—	—	·000½ / ·001¼ = ·013 / ·032	·010 = ·25
Dia. of driving piece (serrated) in bush of crankshaft journal . . .	2·098 / 2·097½ = 53·29 / 53·28	2·095 = 53·21	·002 / ·003 = ·05 / ·076	·005 = ·13
Clearance between driving piece dia. and bush	—	—		
Bore of main drive shaft (crankshaft end)	·907¼ / ·906¼ = 23·00 / 22·97	·911 = 23·14	·002¼ / ·003¾ = ·957 / ·095	·007 = ·18
Dia. of spring drive spindle at crank-shaft end	·904 / ·903½ = 22·96 / 22·95	·899¼ = 22·85		
End float between inner and outer races of main shaft ball bearing .	—	—	—	·008 = ·20

Description.	Dimensions, New. in.	mm.	Permissible Worn Dimensions in.	mm.	Clearance, New. in.	mm.	Permissible Worn Clearance. in.	mm.
FUEL PUMP								
Bore of driving gear bush . .	·563½ / ·562½ =	14·31 / 14·29	·566	14·38	·000½ / ·002 =	·013 / ·05	·004 =	·10
Dia. of gland housing . . .	·562 / ·561½ =	14·27 / 14·26	·558½ =	14·18				
Dia. of pump driving spindle . .	·437 / ·436¾ =	11·1 / 11·09	·434 =	11·02	·001	· / ·038	·004 =	·10
Bore of gland housing and spindle bush	·438¼ / ·438 =	11·13 / 11·125	·441 =	11·20				
Bore of pump driven gear wheel .	·813 / ·812½ =	20·65 / 20·64	·815½ =	20·71	·001 / ·002 =	·025 / ·05	·004 =	·10
Dia. of pivot bush for driven gear wheel	·811½ / ·811 =	20·61 / 20·60	·808½ =	20·53				
Bore of casing recess for pump gears .	1·420 / 1·418	36·07 / 36·02	1·442½ =	36·13	·001½ / ·004½ =	·038 / ·11	·006 =	·15
Dia. of pump gears over teeth . .	1·416½ / 1·415½ =	35·98 / 35·95	1·412 =	35·86				
Depth of casing recess for pump gears	/ ·650	16·52 / 16·51			·001 / ·002	·025 / ·05	·003 =	·076
Depth of pump gear. . . .	·649	16·48 / 16·47						
Backlash between pump gears . .					·003 / ·005 =	·076 / ·13	·010 =	·13
Dia. of gun gear shaft . . .	·593 / ·592	15·06 / 15·04	·588¾ =	14·95	·000¾ / ·002¾ =	·019 / ·066	·005 =	·13
Bore of bush for gun gear shaft .	·594¾ / ·593¾ =	15·11 / 15·08	·598 =	15·19				
a OIL PUMPS								
Bore of bushes for main drive gear shaft	·626½ / ·626 =	15·91 / 15·90	·629¾	16·0	·001¼ / ¼ =	·03 / ·057	·005 =	·13
Dia. of main drive gear shaft . .	·624¾ / ·624¼ =	15·87 / 15·86	·621	15·77				
Bore of bush in pump gear .	·501 / ·500	12·73 / 12·70	·504	12·8	·001 / ·003	·025 / ·076	·005 =	·13
Dia. of spindle. . . .	·499 / ·498	12·67 / 12·65	·495	12·57				
Bore of casing recess for pump gear .	1·444 / 1·443	36·67 / 36·65	1·452 =	36·88	·001 / ·002½ =	·025	·010 =	·25
Dia. of pump gear over teeth . .	1·442 / 1·441½	36·63 / 36·61	1·433 =	36·4				
Depth of scavenge pump casing recess	1·552 / 1·551	39·42 / 39·40			·001	·025 / ·076	·005 =	·13
Width of scavenge pump gear wheel .	1·550 / 1·549	39·37 / 39·34						

a When pump gear recess is worn, the depth may be reduced (but not below the new minimum dimensions) by carefully scraping the joint face.

Description.	Dimensions, New.	Permissible Worn Dimensions.	Clearance, New.	Permissible Worn Clearance.
	in. m.n.	in. mm.	in. mm.	in. mm.
Depth of casing recess of pressure pump gear	$\frac{1·302}{1·301} = \frac{33·07}{33·04}$	—	$\frac{·001}{·003} = \frac{·025}{·076}$	·005 = ·13
Width of pressure pump gear . .	$\frac{1·300}{1·299} = \frac{33·02}{32·99}$	—		
Backlash between pump gears . .	—	—	$\frac{·005}{·007} = \frac{·13}{·18}$	·012 = ·30
Backlash between gears which couple scavenge pumps	—	—	$\frac{·004}{·008} = \frac{·10}{·20}$	·012 = ·30
COOLING LIQUID PUMP				
Dia. of rotor shaft	$\frac{·498}{·497\frac{1}{2}} = \frac{12·65}{12·64}$	·494 = 12·55	$\frac{·002}{·003\frac{1}{2}} = \frac{·05}{·09}$	·006 = ·15
Bore of rotor shaft bushes. . .	$\frac{·501}{·500} = \frac{12·73}{12·7}$	·504 = 12·8		
Clearance between each side of rotor and casings	—	—	$\frac{·025}{·035} = \frac{·63}{·89}$	—
End float of rotor	—	—	·010 = ·25	·020 = ·51
REDUCTION GEAR				
*End float of airscrew shaft . .	—	—	$\frac{·002}{·004} = \frac{·05}{·10}$	·006 = ·15
†Lack of truth of front end of airscrew shaft when shaft is supported on V blocks at the main roller bearing positions.				
Clearance on dia. between roller bearings and outer race. (Pinion or airscrew shaft)	—	—	$\frac{·001}{·001\frac{1}{4}} = \frac{·025}{·032}$	·003 = ·076
Side clearance between roller bearings and inner race on airscrew shaft .	—	—	$\frac{·000\frac{3}{4}}{·002\frac{1}{4}} = \frac{·019}{·057}$	·004 = ·10
End float of rear roller bearing outer race in housing	—	—	$\frac{·005}{·010} = \frac{·13}{·25}$	·015 = ·38
Fit between airscrew shaft and inner race of roller bearings . . .	—	—	—	None
Backlash between main drive pinion and gear	—	—	$\frac{·012}{·014} = \frac{·30}{·36}$	·020 = ·51
End float of outer races in pinion housings	—	—	$\frac{·005}{·010} = \frac{·13}{·25}$	·015 = ·38
Clearance between roller bearings and sides of pinion track . . .	—	—	$\frac{·000\frac{3}{4}}{·001\frac{3}{4}} = \frac{·02}{·044}$	·004 = ·1
End float of locating bearing, inner race	—	—	$\frac{·003}{·007} = \frac{·076}{·18}$	·010 = ·25
End float of locating bearing, outer race and nut	—	—	$\frac{·002}{·020} = \frac{·05}{·5}$	·025 = ·63
Backlash between splines (coupling shaft in pinion)	—	—	—	·005 = ·13

† This may be as much as ·002½ in. (·06 mm.). Total dial indicator reading = ·005 in. (·013 mm.).

Description.	Dimensions, New.		Permissible Worn Dimensions.		Clearance, New.		Permissible Worn Clearance.	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.
Backlash between splines (coupling shaft in crankshaft) . . .	—		—		—		·005 =	·13
HAND STARTER								
Bore of worm shaft bushes . .	·876/·875 =	22·25/22·22	·879 =	22·33	·001/·003 =	·025/·076	·005 =	·13
Dia. of large end of worm shaft .	·874/·873 =	22·3/22·17	·870 =	22·1				
Bore of worm shaft bush . . .	·801/·800 =	20·35/20·32	·804 =	20·42	·001/·003 =	·025/·076	·005 =	·13
Dia. of small end of worm shaft. .	·799/·798 =	20·29/20·27	·795 =	20·19				
ENGINE SPEED INDICATOR DRIVE								
Bore in housing and housing bush .	·531¾/·531¼ =	13·51/13·49	·535 =	13·59	·001½/·002¼ =	·026/·057	·005 =	·13
Dia. of drive gear boss and drive gear shaft	·530/·529½ =	13·46/13·45	·526½ =	13·37				
End float of speed indicator gear .	—		—		·002/·017 =	·05/·43	·025 =	·06
Width between flats across inside of rocker cover.	1·126/1·125 =	28·6/28·57	1·129 =	28·68	·001/·003 =	·025/·076	·005 =	·13
Width of housing	1·124/1·123 =	28·55/28·52	1·120 =	28·45				
Backlash between driving gears. .	—		—		—		·008 =	·2
SUPERCHARGER, INCLUDING ELECTRIC GENERATOR DRIVE								
†Bore of floating bush for drive gears.	·750½/·750 =	19·06/19·05	·752 =	19·1	·001/·002 =	·025/·05	·003 =	·076
†Dia. of intermediate gear shaft .	·749/·748½ =	19·02/19·01	·747 =	18·97				
†Bore of casing lining bush . .	·907½/·907 =	23·05/23·04	·909½ =	23·09	·000¾/·001¾ =	·02/·045	·003 =	·076
†Dia. of floating bush for drive gears .	·906¼/·905¾ =	23·02/23·01	·904 =	22·96				
End float of shaft in bushes . .	—		—		·008/·012 =	·2/·3	·020 =	·51
Radial clearance between lugs on slipper drive pads and side plates .	—		—		·020/·030 =	·51/·76	·010 =	·25
Radial clearance between top of driving segments and bottom of clutch groove	—		—		·025 =	·63	·010 =	·25
Side clearance of driving segments inside plates.	—		—		·005/·008 =	·13/·2	·012 =	·3
Bore of slipper gear bush . . .	1·281¾/1·281¼ =	32·56/32·54	1·283½ =	32·6	·001½/·002¼ =	·026/·057	·003½ =	·089
Dia. of guide plate boss . . .	1·280/1·279½ =	32·51/32·5	1·277¾ =	32·46				

† Combined clearances must not exceed ·004 (·10 mm

Description.	Dimensions, New.		Permissible Worn Dimensions.		Clearance, New.		Permissible Worn Clearance.	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.
Bore of rotor shaft inner floating bush	·500¼ / ·500	12·71 / 12·7	·501¼	= 12·73	·000¼ / ·000¾	= ·006 / ·02	·001½	= ·038
Dia. of rotor shaft	·599¾ / ·499½	12·694 / 12·687	·498½	= 12·66				
Bore of rotor shaft outer floating bush	·600¼ / ·600	15·25 / 15·24	·601¼	= 15·27	·000¼ / ·000¾	= ·006 / ·02	·001½	= ·038
Dia. of rotor shaft inner floating bush.	·599¾ / ----	= 15·233 / 15·227	·598½	= 15·2				
Bore of rotor shaft flanged bush .	·718$\frac{6}{10}$ / ·718$\frac{4}{10}$	= 18·252 / 18·247	·719½	= 18·28	·000$\frac{4}{10}$ / ·000$\frac{9}{10}$	= ·01 / ·023	·001½	= ·038
Dia. of rotor shaft outer floating bush.	·718 / ·717$\frac{7}{10}$	= 18·237 / 18·23						
Total end clearance between rotor shaft and bushes					·025	= ·63	·035	= ·89
End float between inner and outer races of rotor ball bearing . . .							·006	= ·15
Bore of floating bush for gear shaft .	·750	19·06 / 19·05	·753	= 19·13	·001 / ·002	= ·025 / ·05	·004	= ·1
Large dia. of generator drive gear shaft	·749	19·02 / 19·01	·746	= 18·95				
Bore of bush in casing . . .		23·05	·908¾	= 23·08	000¾ / 001¾	= ·02 / ·044	·002½	= ·06
Outside dia. of bush for generator gear shaft	·906¼ / ·905¾	= 23·02 / 23·01	·904½	= 22·97				
Bore of floating bush for gear shaft .		= 16·28 / 16·27	·643	= 16·33	·000$\frac{6}{10}$ / ·001$\frac{6}{10}$	= ·015 / ·04	·003	= ·076
Small dia. of generator drive gear shaft	·640 / ·639½	= 16·26 / 16·25	·637$\frac{6}{10}$	= 16·19				
Bore of bush in casing . . .	·782½ / ·782	= 19·87 / 19·86	·783¾	= 19·91	00¾ / 01¾	= ·02 / ·044	·002½	= ·06
Outside dia. of bush for gear shaft .	·781¼ / ·780¾	= 19·84 / 19·83	·779½	= 19·8				
End float of gear shaft in bushes .					·008 / ·012		·020	= ·51
End float of idler and eccentric shaft ball race							·006	= ·15
End float of bearing on generator drive gear shaft							·006	= ·15
Backlash between any pair of gears .					·004 / ·006	·10 / ·15	·010	= ·25
Bore of throttle spindle bushes .	·500½ / ·500	= 12·71 / 12·7	·504	= 12·8	·001 / ·002½	= ·025 / ·06	·005	= ·13
Dia. of throttle spindle .	·499 / ·498	= 12·67 / 12·65	·495	= 12·57				
CARBURETTERS								
End movement of float pivots .					·010 / ·020	·25 / ·51	·030	= ·76

Description.	Dimensions, New. in.	mm.	Permissible Worn Dimensions. in.	mm.	Clearance, New. in.	mm.	Permissible Worn Clearance. in.	mm.
Bore of float pivot bush	·188 / ·187½	4·78 / 4·76	·190	4·83	·001 / ·002	·025 / ·05	·003½	·09
Dia. of float pivot	·186½ / ·186	4·74 / 4·72	·184	4·67				
Bore of mixture control valve sleeve .	·313 / ·312½	7·95 / 7·94	·316	8·03	·001 / ·002½	·025 / ·06	·004½	·114
Bearing dia. on mixture control valve stem	·311½ / ·310½	7·91 / 7·89	·308	7·82				
Bore of accelerator pump jet recess in carburetter casing. . . .	·625½ / .625	15·88 / 15·87	·630	16·00	·003 / ·003½	·08 / ·09	·008	·20
Dia. (large) of needle valve jet for accelerator pump	·622 / ·621½	15·80 / 15·79	·617	15·67				
Bore of accelerator pump plunger bearing	·500½ / ·500	12·71 / 12·70	·503½	12·79	·001½ / ·002½	·04 / ·06	·005	·13
Large dia. of accelerator pump plunger shaft	·498½ / ·498	12·66 / 12·65	·495	12·57				
Bore of spring seating at lower end .	·407¼ / ·406¼	10·34 / 10·32	·411	10·44	·001¼ / ·003¼	·032 / ·082	·006	·15
Small dia. of pump shaft . .	·405 / ·404	10·29 / 10·26	·400¼	10·17				
Bore of pump piston	·500½ / ·500	12·71 / 12·7	·504	12·80	·001 / ·002½	·025 / ·06	·005	·13
Dia. of spring seating hub. . .	·499 / ·498	12·67 / 12·65	·495	12·57				
Bore of piston bush	1·376 / 1·375	34·95 / 34·92	1·380	35·05	·003 / ·005	·076 / ·13	·008	·20
Dia. of piston	1·372 / 1·371	34·85 / 34·82	1·367	34·72				
Bore of control shaft bearing .	·407¼ / ·406¼	10·34 / 10·32	·411	10·44	·001¼ / ·003¼	·032 / ·082	·006	·15
Dia. of control shaft.	·405 / ·404	10·29 / 10·26	·400¼	10·17				
LOW PRESSURE AIR COMPRESSOR DRIVE								
Bore of drive shaft bush . . .	1·126 / 1·125	28·60 / 28·57	1·129	28·68	·001 / ·003	·025 / ·076	·005	·13
Dia. of drive shaft	1·124 / 1·123	28·55 / 28·52	1·120	28·45				
Backlash of gears	—		—		·004 / ·006	·10 / ·15	·010	·25
AUTOMATIC BOOST REGULATOR								
Bore of relay operating cylinder .	3·500½ / 3·500	88·91 / 88·90	3·503	88·98	·002 / ·003	·05 / ·076	·005	·13
Dia. of relay operating piston . .	3·498 / 3·497½	88·85 / 88·84	3·495	88·77				
Bore of cover extension in relay cylinder	1·001 / 1·000	25·43 / 25·40	1·004	25·5	·001 / ·003	·025 / ·076	·005	·13
Dia. of relay piston rod . . .	·999 / ·998	25·37 / 25·35	·995	25·27				

Description.	Dimensions, New. in.	Dimensions, New. mm.	Permissible Worn Dimensions. in.	Permissible Worn Dimensions. mm.	Clearance, New. in.	Clearance, New. mm.	Permissible Worn Clearance. in.	Permissible Worn Clearance. mm.
Bore of bush for aneroid-controlled piston valve	·438 / ·437½	11·13 / 11·11	·440½	11·19	·002 / ·003	·05 / ·076	·005	·13
Dia. of aneroid-controlled piston valve	·435½ / ·435	11·06 / 11·05	·432½	10·99				
Overlap of aneroid valve outer edges and ports in bush (delivery pressure)	·003	·076						
Overlap of aneroid valve inner edges and ports in bush (suction pressure)	·001	·025						
Bore in cover (for cut-out valve)	·375½ / ·375	9·54 / 9·53	·379	9·63	·001 / ·002	·025 / ·05	·005	·13
Dia. of cut-out valve	·374 / ·373½	9·50 / 9·49	·370	·940				
Bore of bush for change-over cock		17·48 / 17·46	·689½	17·51	·000½ / ·01½	·013 / ·038	·002½	·063
Dia. of change-over cock body	·687	17·45 / 17·44	·685	17·40				
Bore in cover of change-over valve for spindle	/ ·437½	11·14 / 11·11	·441½	11·21	·001 / ·003	·025 / ·076	·005	·13
Dia. of change-over valve operating spindle	·436½ / ·435½	11·09 / 11·06	·432½	10·99				
Bore of pin holes for aneroid valve universal coupling	/ ·156$\frac{2}{10}$	3·98 / 3·968				·005 / ·003		
Dia. of pins in aneroid valve universal coupling	·156 / ·155½	3·962 / 3·95						
Bore of bushes for relay operating spindle	·500½ / ·500	12·713 / 12·7	·503	12·78	·002 / ·003	·05 / ·076	·005	·13
Dia. of spindle for relay operation	·498 / ·497½	12·65 / 12·64	·495	12·57				
Bore of bush in lever which connects link from relay piston	·188 / ·187½	4·775 / 4·763	·189½	4·81	·000 / ·001	·000 / ·025	·002	·05
Dia. of pin in fork of connecting link	·187½ / ·187	4·763 / 4·75	·185½	4·71				
Bore for pin in end of relay piston rod	·188½ / ·187½	4·79 / 4·763	·191½	4·864	·001 / ·003	·025 / ·076	·005	·13
Dia. of pin in end of relay piston rod	·186½ / ·185½	4·74 / 4·71	·182½	4·646				

REMOVING ENGINE FROM AEROPLANE

Although not directly part of this article of describing the complete engine overhaul, a brief description of isolating the engine from the aeroplane is not out of place.

Emptying the fuel, cooling and lubricating systems is taken for granted.

Remove airscrew from the airscrew boss.

Remove cowlings and carburetter air intakes.

Disconnect fuel, cooling and lubricating pipes in systems, exhaust manifolds (if any), crankcase breather piping, ignition switches wiring, tachometer, boost gauge and all piping, main mixture lever and fuel controls, hand-starter fittings, and any auxiliary drives.

Remove holding-down bolts, and with engine clear for slinging, attach ropes as shown in Fig. 1.

It is important that the slings are arranged as shown, the forward sling passing below the rear of the reduction gear casing and avoiding the oil pipe, whilst the rear sling passes round the engine as far to the rear as possible but binding on the lower half of the crankcase just in front of the portion housing the oil pumps. Where the slings pass up against the cylinders, soft packing should be inserted to prevent any damage by the slings.

Swing and secure the engine into a cradle which will permit rotation and locking in at least four positions, viz. :—

The normal upright position.

With the " A " side cylinder block vertical.

With the " B " side cylinder block vertical.

With the engine inverted.

The cradle should be so arranged that the longitudinal bearers and engine-feet brackets do not obstruct removal and insertion of the lateral crankshaft-bearing bolts.

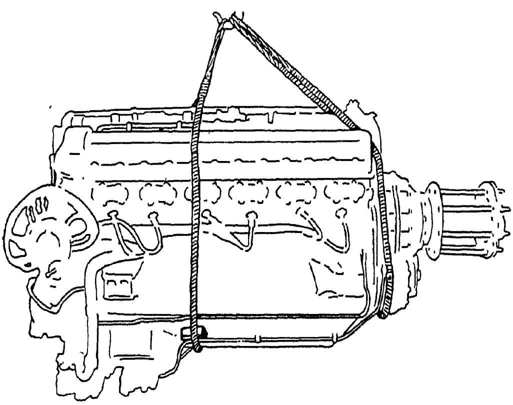


Fig. 1.—SHOWING POSITION OF ROPES WHEN SLINGING.

Dismantling

Since organisation and shop layout for complete overhaul is not part of this article, we are concerned with viewing and repair operations only. One or two notes, however, are worthy of being stated.

Inspection of repair log for indications as to any unusual features in the engine life requiring special investigation at complete overhaul.

During the stripping of the engine, in addition to checking backlash of gears, a suitable opportunity is afforded to note the general condition; intelligent observation will often bring to light a defect in its early stage.

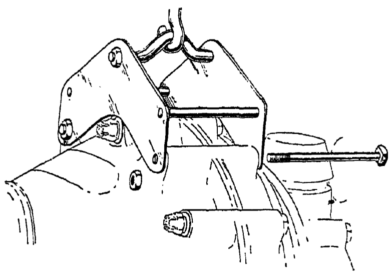


Fig. 2.—LIFTING REDUCTION GEAR.

Metal tallies stamped with the engine number should be attached to the various parts for identification purposes.

With the engine at its entry position for dismantling, proceed as follows :—

Airscrew Hub and Reduction Gear

Remove hub with special ring spanner and protect thread on airscrew shaft with a cap.

At this stage the clearance of the gears should be checked.

Remove oil pipe and two bolts from the top of the casing to attach

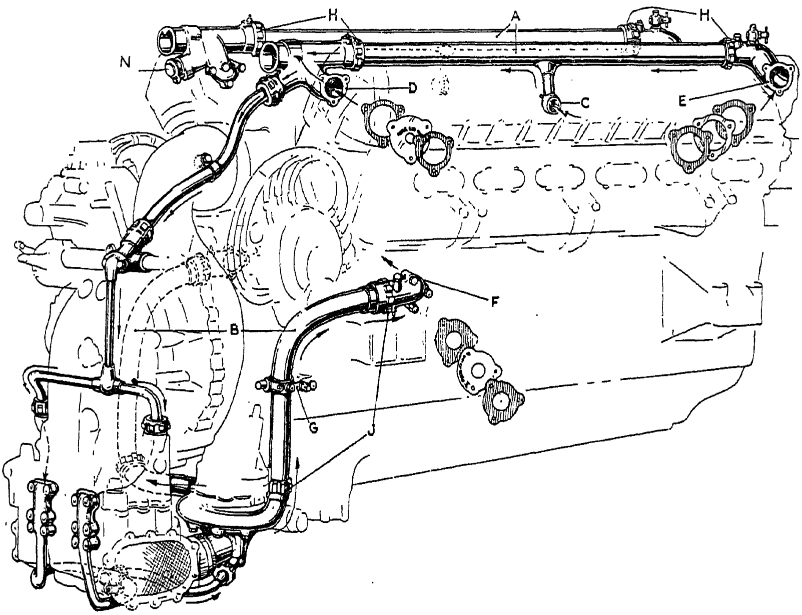


Fig. 3.—ENGINE COOLING LIQUID SYSTEM.

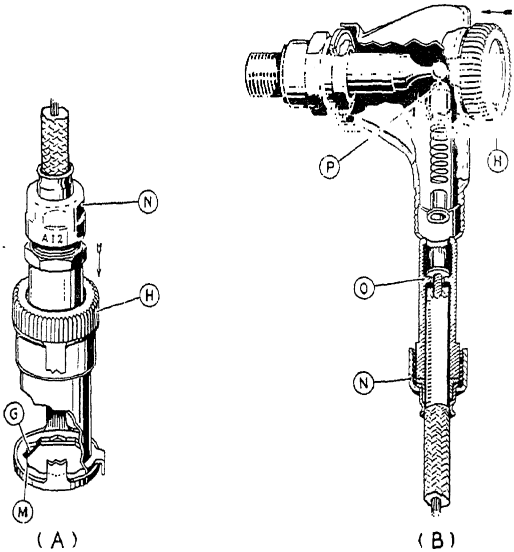


Fig. 4.—HIGH TENSION PLUGHEADS.

the special lifting tool. Remove large bolt on boss through breather casing, and all nuts and bolts holding gear. Withdraw unit and detach drive coupling. A dummy coupling should now be engaged with the serrations in the crankshaft for turning the engine when required.

Cooling Liquid Pipes

After freeing support brackets by releasing rear main lateral bolts " G " (Fig. 3) remove top and side pipes.

At this stage it is advisable to add dummy covers to liquid pump outlets to prevent small parts dropping in to damage the impellor.

Priming and Volute Drain Pipes

Detach the two pipes leading from the main priming and volute connections. Remove the nuts securing four clips to the manifolds. Take off the eight nuts which secure dual connections to the manifold, remove plates and atomizers. Take off the two centre nuts and remove piping unit. Remove clips and disconnect " Petroflex " drain pipe which connects the top manifold with the venturi on the carburetter intake.

Ignition Wires and Magnetos

Remove all high-tension plug leads. Detach ignition wire brackets and clips from cylinder blocks and induction manifolds, and remove magneto distributors, complete with wiring, disconnect controls. Remove magnetos and take out loose drive shafts.

Remove screened fittings to sparking plugs and unscrew the plugs.

Note. The plug ends are marked with corresponding cylinder numbers for the " A " and " B " units.

Supercharger, Carburetter, Boost Regulator and Controls

By unscrewing gland nuts disengage the supercharger from the

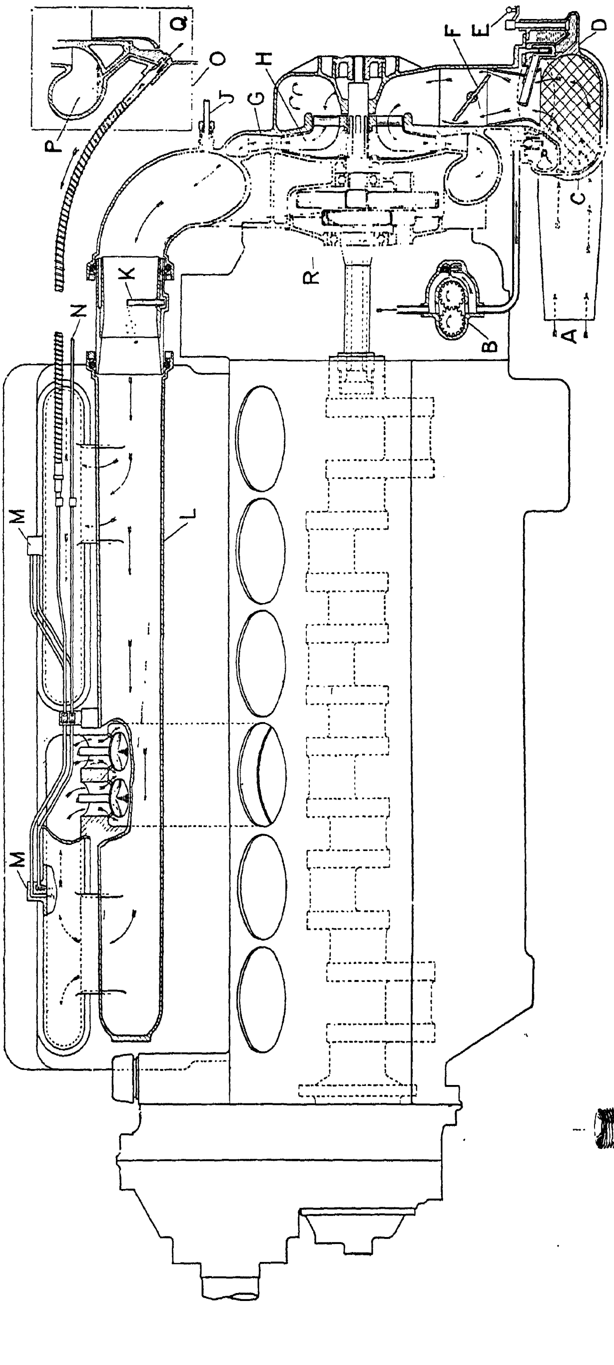


Fig. 5 (*above*).—SUPERCHARGER AND CARBURETTER SYSTEM.

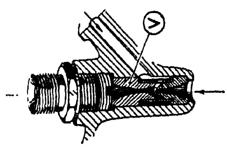


Fig. 6 (*left*).—VOLUTE DRAIN VENTURI.

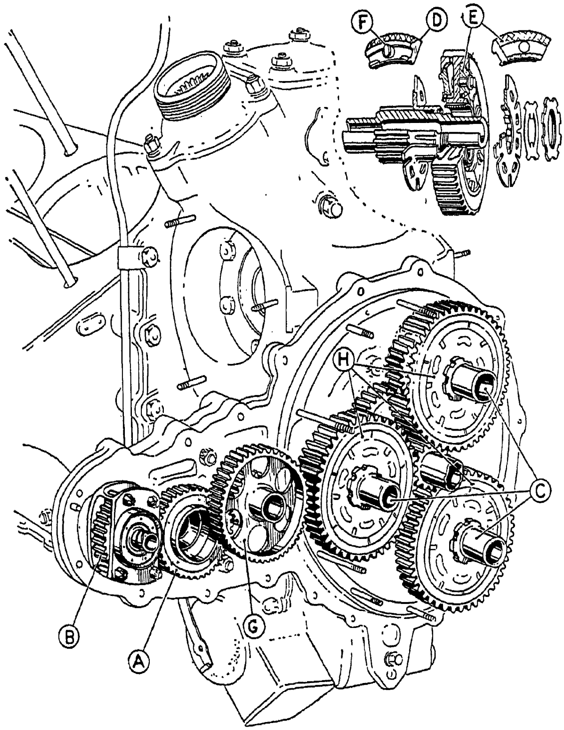


Fig. 7.—SUPERCHARGER AND DYNAMO GEARS.

manifold. Remove the auxiliary cooling system pipes from the pumps and top outlet pipe (see Fig. 3). Remove oil-feed pipes to supercharger rear bearing and gears.

Remove supercharger securing nuts and withdraw the unit bodily with great care.

Spring Drive, Hand Starter, Supercharger and Dynamo Drive Gears

After unscrewing the securing nuts the casing should be removed, also the gears. The gears are freely mounted on floating bushes, and care, therefore, must be taken that they do not fall out. They should be restored in their original positions, so care should be taken to note their respective location (Fig. 7).

The hand-starter gear, friction clutch and serrated spring drive will be withdrawn bodily with the casing.

Separate this unit from the casing by removing bolts " N " (Fig. 25).

If a gas starter is used the pipes, distributor and coupling should now be removed from the right-hand rocker cover.

Similarly, remove the engine speed indicator drive from the left-hand rocker cover (Fig. 2, p. 268, Vol. II).

Induction Manifold

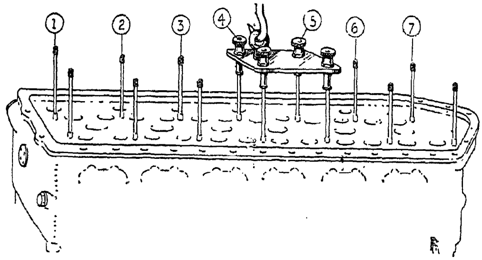
These may be lifted clear of the cylinder blocks, after removing the nuts which secure them to the blocks and induction trunk (see Fig. 5).

The induction trunk should be withdrawn from between the cylinder blocks after the manifold branches have been removed.

Note. Do not use metal tools for parting joints.

Rocker Covers

After removing the nuts the rocker covers should be lifted.



8.—LIFTING CYLINDER BLOCK.

Test Backlash of the Camshaft Drive Bevel Gears

At this stage it is convenient to test the backlash of the camshaft drive bevel gears.

Remove castellated nuts securing camshaft and rocker brackets to cylinder blocks (fourteen on each block) and lift off as a complete unit. (The camshaft has to be removed to expose the cylinder block holding-down nuts.)

Upper Camshaft Drive

Loosen two of the nuts retaining the lower parts of these drives, free the lock plate and unscrew lower serrated retaining nut from housing in wheel case. Take off top cover " C " (Fig. 27) which retains serrated drive shaft. Slack off upper gland nut after removing spring circlip. Guard tube " A1 " (Fig. 27) should now be pushed up and the serrated drive lifted to disengage the serrations. Remove lock plate and nut " B " (Fig. 27) which retains upper housing in cylinder and locking clip " O " (Fig. 27) which is in halves. The whole unit should then be tapped (not using a metal tool) and withdrawn from the cylinder housing. This leaves the lower part of the drive in the wheel case.

Wheel Case

At this stage it is convenient to check the backlash of the following gears :—

Lower driving bevels.

Lower camshaft and main driving bevels.

Lower vertical drive shaft and main driving bevels.

Detach camshaft oil-feed pipes, also pipe to gland of fuel pump. The wheel case should now be removed as a complete unit, bolted to the special rig, and during dismantling all other drives checked, the various thickness washers measured and the sizes noted. This will save considerable time when the erection stage is reached.

Detach camshaft oil-feed pipes, also oil pipe to gland of fuel pipe. Remove wheel case complete.

Cylinder Blocks

Rotate engine cradle until one cylinder block side is vertical. This

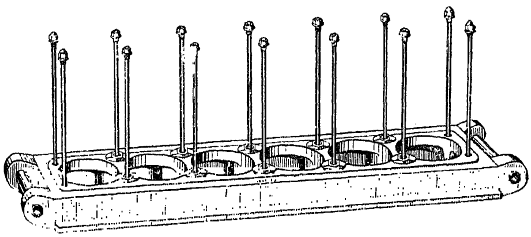


Fig. 9.—CYLINDER BLOCK JIG.

is essential. The crankshaft should now be turned until pistons Nos. 3 and 4 of the vertical block are at T.D.C. This operation is important in order to avoid locking of the lower scraper piston rings in the crankcase when the block is raised.

With special spanner remove the fourteen holding-down nuts.

Attach the special lifting tool, as shown in Fig. 8, to studs of camshaft and rocker brackets Nos. 4 and 5 (counting from airscrew end) with hook adjacent to studs of bracket No. 4.

The block should now be lifted carefully off and placed on a special jig (see Fig. 9) in order to preserve the liner joints. The joint faces must be quite clean and the holding-down nuts should be tightened as they were before the block was removed from the crankcase.

The operations for removing the second cylinder block are the same as for the first.

Pistons

All pistons and piston rings should be removed to avoid risk of breaking, and precautions taken to avoid damage to the connecting rod when the engine is turned to get the second cylinder block vertical for removal.

Detach one gudgeon pin locking-wire from each piston and push each pin up by hand from the opposite end. After removing the pistons the other gudgeon pin locking-wire can be taken out (see Fig. 58).

Crankcase Lower Half, Oil Pumps and Air Compressor

The crankcase should now be turned on the cradle to the inverted position, *i.e.*, with the lower half upwards.

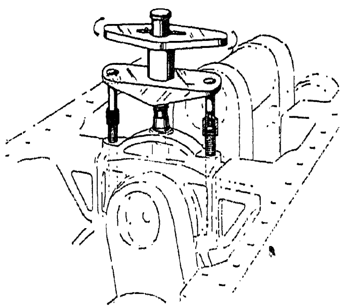


Fig. 10.—EXTRACTING MAIN BEARING CAPS FROM CRANKCASE.

Remove main pressure oil-feed pipe. Remove nuts securing upper and lower half of crankcase and remove the lower half complete with oil pumps and air compressor drive. Take care that the four tubular dowels on four studs are not lost (they should be a light tapping fit). Remove the main oil gallery and connections of each main bearing and record the fit of split pins in big ends.

Crankshaft and Connecting Rods

Check end float of crankshaft in centre bearing. The lateral bolts through the crankcase should now be removed, also the main bearing-cap retaining nuts. Each should be kept to the original stud to which it was fitted. Withdraw the main bearing caps by using an extractor (see Fig. 10).

The crankshaft should now be lifted out complete with the connecting rods, but leaving the lower bearing halves in the crankcase.

To remove the connecting rods take out the big-end bolts from the plain rods first, a soft metal drift may be used if necessary, and after removing the outer half rods will come away. The forked rods should be removed in a similar way. When removing the rods care should be taken not to disturb the bearing metal.

Note. Connecting-rod caps, bolts and nuts should not be interchanged between rods, the assembly should remain the same.

INSPECTION AND REPAIR

If the engine as a whole may be termed a major assembly, then from the dismantling operations mentioned above, it may at this stage be considered as having been broken down into minor assemblies.

Each minor assembly will be described for further dismantling, viewing, repairs and test, if any.

It is taken for granted that after dismantling, all parts are thoroughly cleaned in the various baths according to the metal and component concerned. It is not, however, without interest to mention these baths as follows :—

A degreasing plant may be used where a large number of engines are going to be overhauled consistently.

Where, however, only a few engines are concerned the following baths should be adopted.

First Wash. Steel and Light Alloy Parts. Using 1 lb. of soap (free from soda or other corrosive agents) to 5 gallons of water for the solution, immerse the parts, putting the small articles into a wire basket. Heat the water to a temperature of 90°–95° C. and leave for at least 2 hours. As a precautionary measure it is advisable to have a small piece of duralumin, say 6 in. square, of 16 S.W.G. in the bath to act as a detector for corrosive action. Some soaps though supposed to be free of corrosive agents may yet contain an agent by composition, and so the danger against such action must be avoided. This piece of metal should be examined daily.

Note. Be sure that the soap is in solution before the bath is used.

Second Wash. Steel Parts. Immerse in clean hot water for not less than 30 minutes.

Third Wash. Steel Parts. Wash in clean paraffin, and afterwards

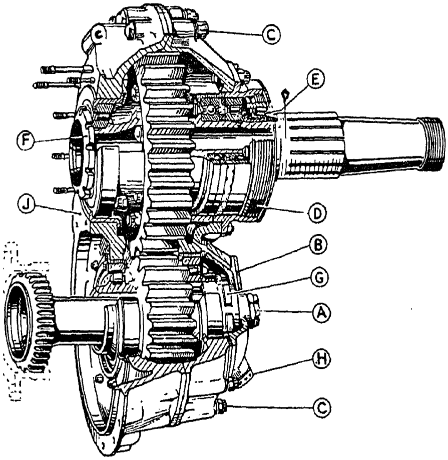


Fig. 11.—REDUCTION GEAR.

see that all surplus paraffin is removed. This is to avoid any chance of corrosive action centring around such places as oilways, for paraffin is not a preventative against such action. For this operation of drying an air blast should be used, and finally all surfaces should be smeared in mineral oil.

Second Wash. Light Alloy Parts. Immerse all parts in a solution of 80 per cent. paraffin and 20 per cent. mineral oil. Heat the liquid to a temperature of approximately 60° C. and leave for at least 30 minutes. The addition of mineral oil is of great assistance in leaving an oil film for definite discolouration when chalk testing is carried out. After removal parts should be left to drain until dry.

Note. Pipe-lines with soldered joints should be cleaned in paraffin only.

Testing for Surface Defects.

Methods for testing components for cracks or material defects are as follows :—

Chalk Test.

This test is generally applied to light alloys. The part to be tested should be painted, using a suitable brush, with a well made mixture of whiting and methylated spirits. Very small cracks will show up by discolouration. (See second wash for light alloy parts above.)

Magna-Flux Test.

This is by far the most extensively used test, and is most reliable for all magnetic materials.

Reduction Gear

This gear is clearly shown in Fig. 11.

Extract split pin and unscrew central nut " A," remove cover " B " retaining nuts and bolts " C " which retain halves of casing. The rear half gear case " J " should then be removed complete with outer roller races.

Going to the airscrew shaft, extract spring locking wire and nut " D ". Bend up tabs of plate and remove retaining nut " E ".

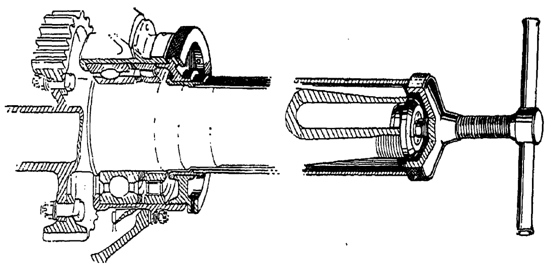


Fig. 12.—EXTRACTING AIRSCREW SHAFT.

Remove the oil seal. Using the special tool which is illustrated in Fig. 12, extract the airscrew shaft from its housing. Remove retaining nut "F" which has a left-handed thread for the inner roller race at the rear end of the airscrew shaft. Remove the race, using the special extractor as shown in Fig. 13. Within the front end of pinion is a ball race secured by a cap "G" (Fig. 11) fitted with a left-handed thread. This ball race only locates the pinion axially.

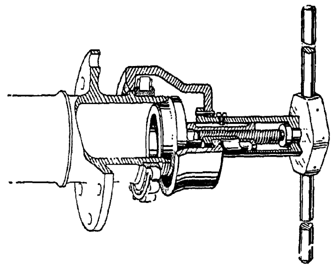


Fig. 13.—REMOVE INNER RACE AIRSCREW SHAFT.

Withdraw the outer races of the airscrew bearing, using the special tool as shown in Fig. 14. The special oil seal ring should be replaced carefully.

The gears are paired and similarly marked in the original grinding operation, and should not, therefore, be interchanged with other gears from other units. If either gear is found on viewing to be outside the limits laid down then both gears should be renewed as a pair.

The ball and roller races should be viewed for wear. Casings tested on faces for distortion and chalk-tested for cracks. Liner and outer races checked for creeping. Check alignment of gears and teeth of splined coupling. Check airscrew shaft for truth.

Note. Should a reduction gear come in for examination

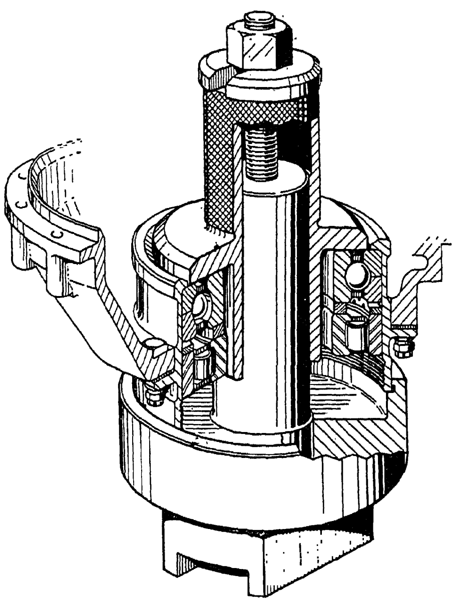


Fig. 14.—WITHDRAWING AIRSCREW SHAFT BEARING.

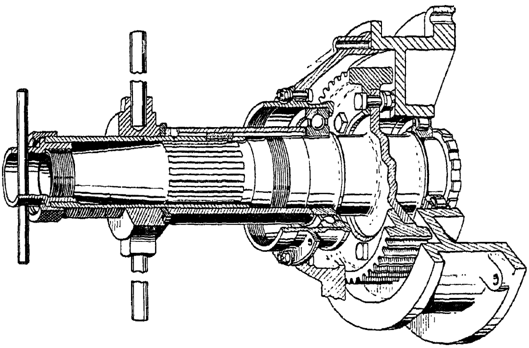


Fig. 15.—ASSEMBLING BEARINGS ON AIRSCREW SHAFT.

after the airscrew has come in contact with the ground, in addition to the above, check crankcase for truth, smear prussian blue or other marking on either gear teeth flanks, build gear, rotate approximately twelve times, dismantle and the bedding as shown by the marking must be parallel to the axis of the crankshaft.

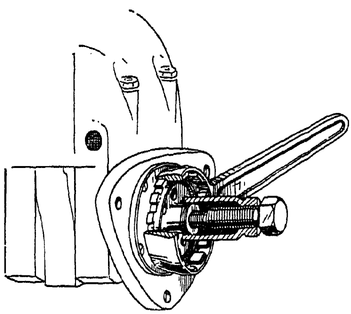


Fig. 16.—REMOVING MAGNETO COUPLING SHAFT.

Using the special tool as shown in Fig. 15, assemble the bearings on the airscrew shaft. When replacing the retaining nut of the shaft-bearing housing see that the distance washer is in position between the nut and outer roller race. When the nut is tightened the washer allows 0·002 in. to 0.004 in. end clearance.

Replace locking wire.

Replace pinion in front half of casing with axial locating ball race and pin in position, and replace the cover " B " and nut " A " (see Fig. 11).

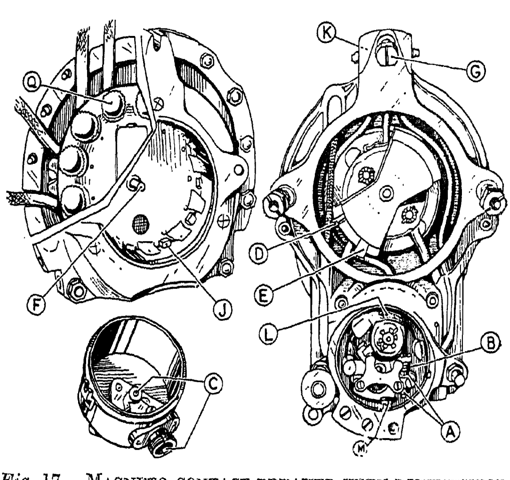


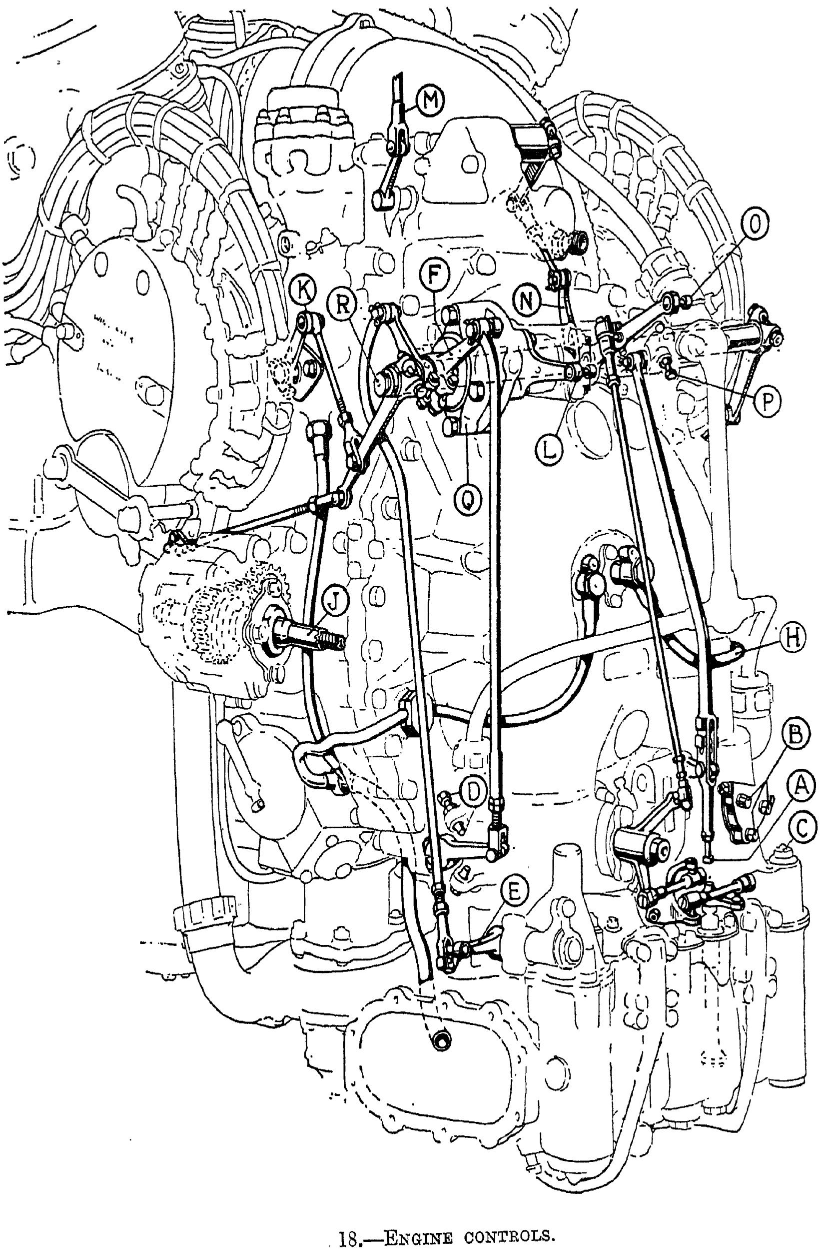
Fig. 17.—MAGNETO CONTACT BREAKER WITH DISTRIBUTOR

Cooling Liquid Pipes

Examine for soundness and corrosive action. Test in water to 15 lbs. per square inch. Check joints for wear and correct alignment.

Priming and Volute Drain Pipes

Examine for soundness, corrosive action,



18.—ENGINE CONTROLS.

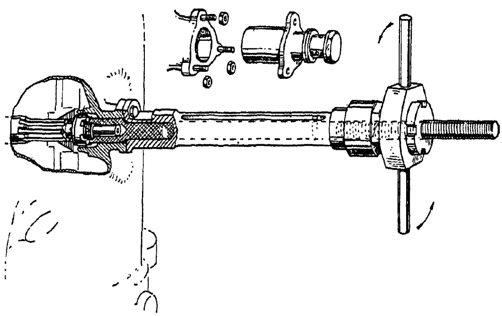


Fig. 19.—SEPARATING SUPERCHARGER CASING.

joints for wear and correct alignment. Renew "Petroflex" piping.

Ignition Wires

All high - tension wires should be renewed. Fig. 4 shows the fittings of the inlet and exhaust plug fittings. The attachments are made as follows: After screwing up plug, engage outer hexagon "G" and push knurled ring "H" (which is spring loaded) until serrations "M" are clear of plug hexagon and can be turned as shown. On releasing pressure the fitting should be secure. The screwed cap "N" (which bears the cylinder number marking) should be checked for tightness, alternately the spring loading of contact "P" should be checked inside bakelite fitting "O".

A new set of sparking plugs should be fitted and the final gap adjusted to 0·012 in. (maximum). Setting these gaps should be done with a soft gauge; it is most inadvisable to use any tool that will strain the electrodes when being tried by a gauge.

Magnetos

Remove the coupling flange as shown in Fig. 16.

Dismantle and examine all parts. Remagnetise the magnets, test the insulation of the wiring, and if defective renew as a whole. Test all circuits. Renew contacts and brushes where necessary. Strip and examine contact breaker. Particular attention should be given to the points and the movement of the contact breaker. In most cases it is desirable to renew these parts and the bushes on which they turn. Examine carefully the faces of the cams for operating the contact breaker and ensure that the contours are concentric. The final adjustment of the contact-breaker gap should be 0·011 in.

Examine the main bearings for wear, and ensure that they are within the limits.

Examine the distributor pick-up for pitting and ensure concentricity.

Fig. 17 shows a magneto with the contact breaker and distributor removed.

Supercharger, Carburetter, Boost Regulator and Controls

Engine Controls. Fig. 18 shows the general arrangement of the control mechanism which should be dismantled from the supercharger

and carburetter casings. All rods should be examined for soundness and ball joints for wear, renewing as necessary. The correct settings of the rods with their respective clearances should be noted in connection with wear. On replacement, final adjustments are made after installation, and will be described later. (The description could be read conveniently at this point before proceeding, see notes headed "Installation" at end of article.)

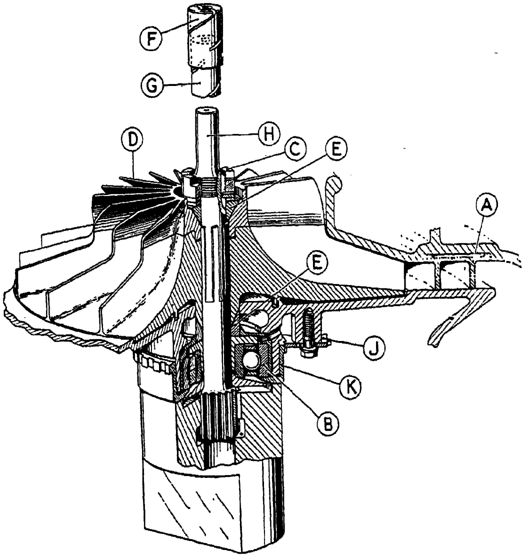


Fig. 20.—SUPERCHARGER IN VICE BLOCK.

The main shaft should be examined for wear on its bearings. It is very important that the fit of this shaft is strictly according to the limits laid down. Invariably the shaft and bearings should be renewed.

The controls having been removed, the pipes to the carburetter jacket should now be taken off, examined for soundness and any effects of corrosive action. The lower part of the carburetter and the boost regulator as a unit should now be carefully removed.

Supercharger. The supercharger casing should be parted after the retaining nuts have been removed, and using a special tool as shown in Fig. 19.

This last operation will also free the diffuser vane ring "A" (see Fig. 20).

The rotor ball-bearing "B" is carried in the forward casing.

Examine the rotor blades for any damage or surface cracks, the slightest sign of which necessitates the fitting of a new rotor. The rotor must be perfectly balanced, using an apparatus of the knife-edge type, and must be balanced completely with spindle and details.

If the shaft is mounted in a vice block carefully (see Fig. 20), slotted nut "C" may be unscrewed and the shaft tapped out. This will free the steel guide ring "D" rotor and taper pieces "E".

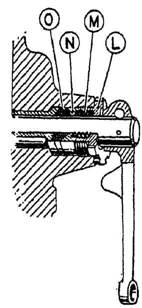


Fig. 21.—THROTTLE SPINDLE GLAND.

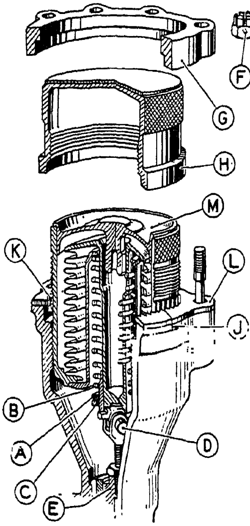


Fig. 22.—ANEROID UNIT.

Detach locking plate " J ", remove retaining nut " E " and tap out ball bearing from the rear end. Examine this bearing for wear.

Examine the serrated end of the rotor shaft for fit, and at the other end examine carefully the tail-bearing bushes " F " and " G " for wear and float.

Chalk test the casing for soundness and any effects of corrosive action.

Dismantle the throttle spindle-gland after taking out the six hexagon screws and butterfly throttles. Fig. 21 shows a section of the gland, and it is important that the correct order of packing " O ", ring " N ", spring " M " be retained.

Assemble the supercharger carefully with the same vane ring and the correct *nip* when bolting up casings.

Boost Regulator. Carefully remove aneroid unit and piston valve. Examine the flexible metallic bellows, using a magnifying glass. No repair work can be carried out on these bellows, and the fatigue limit can only be found out by experience. If any defects are found the unit must be changed as a whole.

Note. The adjusting washer for de-rating is shown at " A " in Fig. 22.

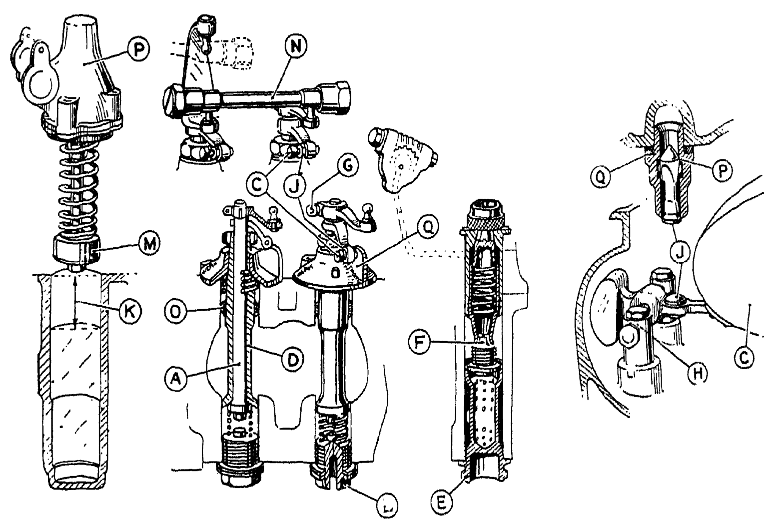


Fig. 23.—CARBURETTER PARTS.

Change of boost rating is described later under "Installation." The piston valve should be examined for wear, and any markings that would interfere with the sharpness of the opening or closing actions over the ports.

Similar remarks apply to the relay piston, atmospheric change-over valve and cut-out valve. The differential control should be checked for wear, as also the pins of all joints in the control linkage. The unit should be assembled without change of adjustment. (For diagram see Fig. 10, page 280, Vol. II.)

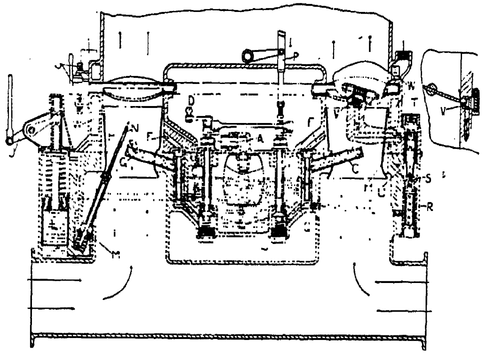


Fig. 24.—DIAGRAMMATIC SECTION OF CARBURETTER. See also Fig. 6, page 276, Vol. II.

Carburetter

The parts of the carburetter requiring special attention are shown in Fig. 23.

The following parts should be removed :—

Main air bleed tubes and nozzles with chokes (downwards).

Unscrew plug, " B " at base, detach top controls and remove main metering valves " A ".

Unscrew slow-running filter " E " and jet " F ", after having removed adjustment screws " B " and knurled cap " C " of Fig. 18.

Accelerator pump " M " and needle valve.

Float " C " and pivots " H ".

Glands " O " and seating " D ".

Thoroughly clean filter and parts, and blow out all passages.

Examine seats of metering valves and valves for abrasion and ensure perfect bedding, also check float spindle for wear and end play.

Examine float cut-off contacts " J ", and polish face of needle valve.

Examine throughout for any effects of corrosive action.

After careful assembly, metering tests should be carried out with pinch bolts " G " left slack and the accelerator pump-cover " P " left off as follows :—

Replace plug and spring below left-hand valve.

Insert specially drilled plug and spring below the right-hand valve.

Turn on the fuel supply and vary the rotational adjustment of valve until a flow of 1 pint in 53 seconds is recorded in a suitable vessel placed below.

This setting is the " full rich " position, and is determined by the stop screws " C ", which should be then finally locked with nuts " J ".

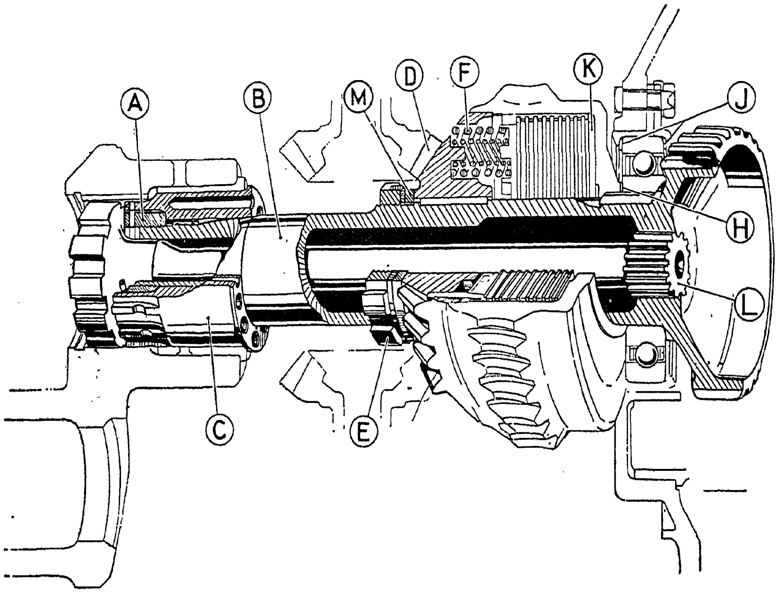


Fig. 25.—SPRING DRIVE AND HAND STARTER.

Turn valve to the "weak" position, at which point the fuel flow should be 1 pint in 164 seconds.

Advance main butterfly throttle lever to the take-off stop "P" (Fig. 18) and adjust point "A" (Fig. 18) until the right-hand valve is depressed to give a fuel flow of 1 pint in 36 seconds. This should be about 0·030 in. to 0·040 in.

Interchange plugs and repeat the first two tests for the other valves. The length of the coupling link "N" need not be altered.

Tighten pinch bolts "G", confirming that stop screws "C" are both against their stops "Q" (Fig. 23).

The importance of checking a clean float cut-off at the correct level is emphasised. The following operations should be carried out :—

Mount carburetter on an adjustable rig, capable of being set dead level in both directions, and check with a spirit level.

Fit an adaptor plate to take the needle valve complete, and an adaptor for coupling of the fuel supply. This plate is fitted to the carburetter instead of bolting the carburetter to the supercharger. Ensure that a packing piece equal to the correct joint thickness is interposed. The fuel level is now exposed and any alteration should be effected by varying the thickness of the washer "Q" (Fig. 23) underneath the needle-valve seating, which should not be tightened excessively or distortion and flooding may result.

The level is given as follows :—

A pressure of 4 lbs. per square inch, the approximate equivalent of a 12-ft. head of fuel, gives dimension "K" of Fig. 23 0·475 in. + 0·025 in. Note dimension "K" is taken from the centre of the meniscus, and that the reading should be checked several times.

During assembly, should flooding result when the carburetter is bolted to the supercharger it may be due to the float fouling the supercharger casing.

The fitting of the boost regulator unit calls for no comment.

When replacing controls at this stage leave the slow-running adjustments free. They are "B", "C" and "D" of Fig. 18, and "T" and "V" of Fig. 24. All final slow-running adjustments should be made after installation.

Spring Drive, Hand Starter, Supercharger and Dynamo Drive Gears

Supercharger and Dynamo Drive Gears (see Fig. 7). Inspect "slipper" gears and floating bushes, the former are carefully balanced and fitted, the segments are marked for assembly.

If the eccentric gear "A" has been removed, note that its original location is restored.

The final drive gear "B" attached to inner casing should also be checked.

Build up complete gear train and check clearances as shown at "D" and "F", also backlash of gears (done by pairs).

Spring Drive and Hand Starter (see Fig. 25). Before stripping check the backlash between the rear end of the spring drive spindle and outer shaft. Then hold the outer shaft on a suitable vice block and unscrew nut "A" fitted with a left-handed thread. Withdraw serrated drive coupling "C" with a special tool.

The main driving bevel is fitted on a slight taper on its shaft and secured by nut "E". Before disturbing this bevel, record its location on the shaft, any departure from its original position will affect the meshing of the lower camshaft and lower vertical drives, also the loading of the clutch springs "F" which determine the setting of the hand-starter clutch.

To indicate the amount that these springs are compressed together two pegs are mounted in the spring pressure plate and project through holes in the bevel. The length of these pegs has been so adjusted that their ends are flush with the outer ends of the springs when the latter are compressed to their working position.

A careful examination should therefore be made of the position of the ends of the pegs relative to the body of the bevel wheel, and, provided that the friction plates are replaced as before (together with certain distance washers to be referred to later) then correct meshing of the bevels and loading of the friction plates will be restored.

An additional record of the position of the bevel on its shaft can be made in the following manner :—

Before disturbing the nut "E" measure the distance of its outer

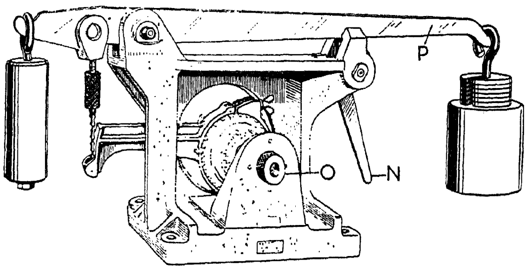


Fig. 26.—TESTING HAND-STARTER CLUTCH.

face from the end of the bearing bush which protrudes from that end of the hollow shaft, also make a small scratch or pencil mark on the face of the nut, and another registering with it on the end of the shaft.

Extract main driving bevel.

Remove hand-starter worm wheel complete with friction plates, presser plate and springs. Check the worm wheel for damage. Invariably this part has to be renewed, being of duralium working against the steel worm.

A distance washer " H " is fitted between back of worm wheel and inner race of ball bearing. Label this for replacement.

Should it be necessary to remove the ball bearing, the distance washers " J " should be labelled showing location in the cover.

Examine all splines for damage. Clutch-plate splines which show signs of burring should be lapped.

Inspect teeth of bevel wheel.

Inspect spur gear portion of guard tube.

See that bevel wheel is free in the mouth of worm wheel.

Inspect ball bearing.

Check backlash between spring drive spindle and crankshaft. Oversize spindles may be fitted. (See Fits and Clearances.)

Reassemble as follows :—

Fit original distance washers " J ", ball bearing to housing and bolt up to casing.

Fit shaft in bearing and mount on special tool.

Fit distance washer against inner race of ball bearing and replace worm wheel.

Oil the clutch plates and replace.

Fit presser plate and springs.

Press main driving bevel into its original position on taper. (The dimension given during stripping should be checked.)

Having restored the original setting of the main bevel and locked it in position, check on the special rig the slip-load torque of the hand-starter clutch (see Fig. 26) as follows :—

Slack off the clamp and engage the unit as illustrated, with lever " N " in the down position. Engage thread of knurled ring nut " O " with thread of main shaft and screw up nut tightly by hand, the casing spigots being engaged with hole in rig. Screw up the clamp-wing nut

and remove all small weights. Apply torque by lifting lever "N" upwards, avoiding any jerking or sudden movement. If the lever "P" falls, then the friction is insufficient and washer "K" (Fig. 25) must be replaced by a thicker one. On the other hand, if, when all six small weights have been added, the lever does not fall, a thinner washer must be selected. The replacement will, of course, necessitate removal and replacement of the bevel gear as described. The torque must be between 5,000 and 5,300 in./lbs., as given by the range of weights supplied.

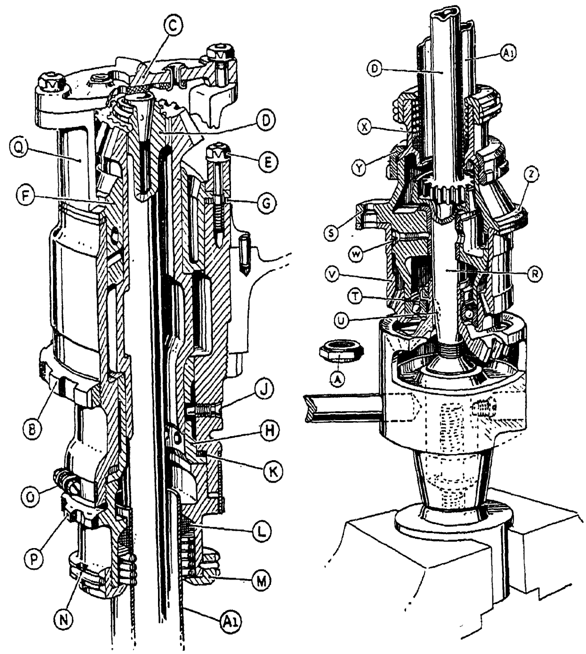


Fig. 27.—CAMSHAFT DRIVE.

Assemble temporarily this unit with the supercharger and dynamo gears and casing.

Induction Manifolds and Trunks

Examine for soundness, alignment of faces, any effects of corrosive action and correctness of joints. Note the re-distribution pipe for condensed fuel and volute drain system ; although the latter is part of the supercharger casing it is convenient to mention it here as part of the induction system (see Fig. 5).

Rocker Covers

These parts will be considered as part of cylinder block minor assembly.

Upper Camshaft Drive

Nut " B " and cover " C " have been removed already, also serrated drive shaft " D ".

Remove split-lock ring " O ", mount unit in a suitable vice block and unscrew gland housing " P " with special spanner.

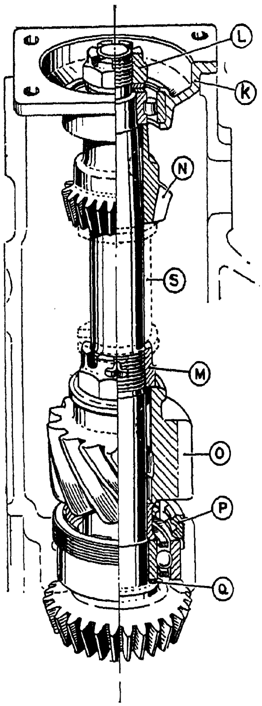


Fig. 28.—LOWER CAMSHAFT DRIVE.

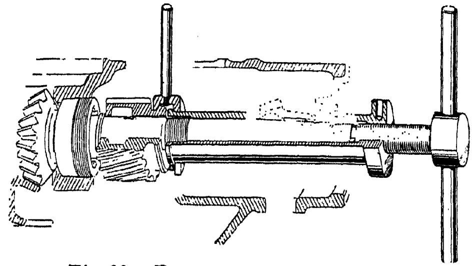


Fig. 29.—REMOVING MAGNETO DRIVE.

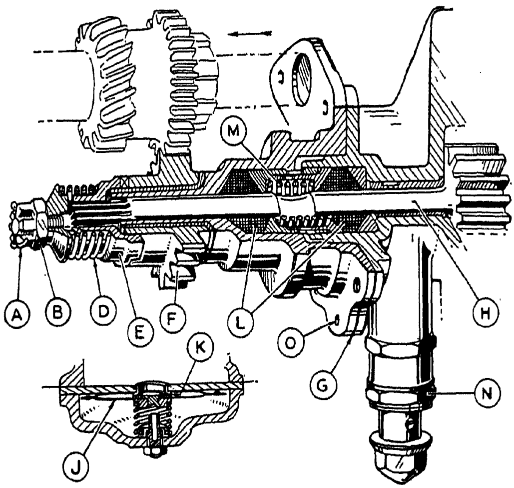


Fig. 30.—FUEL PUMP AND RELIEF VALVE.

Remove top nuts “ E ” retaining cover support-bracket “ Q ”. Lift out upper bevel and bush (split) “ F ”, also washer “ G ”.

Tap out lower bush “ H ” after taking out countersunk setscrew “ J ”. An adjusting washer “ K ” is placed between bush and main housing, and determines engagement of the bevels.

Examine clearances and also gland packing “ L ”, and all parts for wear.

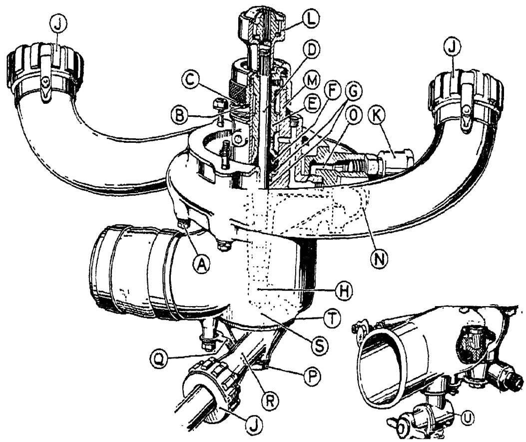
Assemble unit in overhauled cylinder block, but without top cover and nut “ B ”, also leave gland nuts “ M ” loose and without spring circlips “ N ”.

Secure lower gland housing with serrated nut and lock with plate. Screw up gland nuts and lock with spring circlips.

Wheel Case

Lower Part of Upper Camshaft Drive. The parts “ D ”, “ X ” and “ Y ” have been removed already. Detach from wheel case and mount

unit on a suitable vice block (see Fig. 27). Bend tabs of lock washer and unscrew nut "A". The drive spindle "R" should then be forced out, allowing housing "S" and "V" to be separated. "T" is an adjusting washer between ball bearing and housing. Mount bevel wheel in holder, bend back tabs of inner nut and unscrew. Remove bevel wheel from ball bearing by tapping out with a soft drift.



31.—COOLING LIQUID PUMP.

Examine unit for condition, wear on ball bearing and clearances. Plain bush in top half housing may be removed if necessary by taking out set screw "W".

When reassembling care should be taken for each unit which is marked "A" or "B" side to be fitted with the correct paper-joint washer. It is also important that the plain washer and lock plate be added before the spring washers.

Lower Camshaft Drive (see Fig. 28). Remove cover, unscrew castellated nut "L" and pull off top roller bearing and housing "K". Remove split cotter from nut "M" half-way along this shaft and insert special distance piece "S" between nut and upper bevel "N". Unscrew nut "M" (left-hand thread) to press bevel off shaft.

Withdraw magneto drive-gear "O" with special tool and remove two numbered keys, and tap out shaft downwards (see Fig. 29).

The lower ball bearing should now be removed after extracting spring circlip and unscrewing serrated nut "P".

See that adjusting washer "Q" is in position on shaft before replacement.

Hand-Starter Gear Shaft. Remove plug and pin on the one side and nut securing housing on the other, and tap out shaft towards the latter side. Remove plug left in and slide off cover. Remove spring circlip and unscrew serrated nut, allowing housing bushes and ball thrust to be detached. Examine for wear, and especially the condition of the worm.

Magneto Drive. Remove bearing retaining cover from one end of magneto-drive shaft and tap out shaft and bearings from the opposite end. Examine for wear.

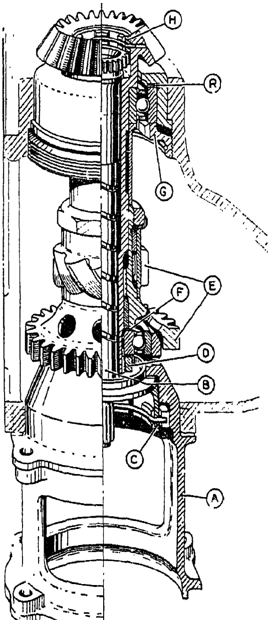


Fig. 32.—LOWER VERTICAL DRIVE.

Fuel Pump and Relief Valve (*Fig.* 30)

Disengage unit from wheel case, remove split pin " A " and nut " B ", and pull off spring " D ", drive coupling " E ", and gear wheel " F ". Part the casings at joint " G " allowing gland to be dismantled and also gear shaft " H " to be removed. Unscrew the oil-feed connection " N ". This is fed from H.P. system and incorporates a non-return valve, which should be washed and blown out. Carefully dismantle the relief valve, and do not distort spring " J ". Examine flat valve faces " K " and clean out all foreign matter.

Examine gear shaft for abrasion marks, and renew packing " L " if necessary.

The two glands are pressed by a single spring " M ", and this should not be omitted when reassembling.

Reassemble carefully and note position of gland parts and drive. The paper joints should not restrict fuel drain hole at " O " or building up of fuel may occur.

Cooling Liquid Pump (see Fig. 31). Detach from wheel case extension, slide off universal connection " L ", unscrew nuts " A ", and part casings. Disengage end of spring " B " from teeth of gland-nut rachet " C ", unscrew gland nut (left-hand thread) and remove rotor and shaft " D ". Carefully take out gland " E ", packing " F ", and inner bushes " G ". Examine rotor blades for cracks and corrosion, and spindle for scoring. Check all clearances and lignum vitæ (hardwood) thrust plug " H ".

By unscrewing nut " P " (remove lock-plate " Q "), connection " R " and thrust plug " H " and its retainer " S " can be separated. Note aluminium joint " T " when assembling.

Examine all rubber-joint rings at points " J " for attack or fretting, and renew if necessary. Replace paper joints between casings. Renew gland packing and assemble as illustrated.

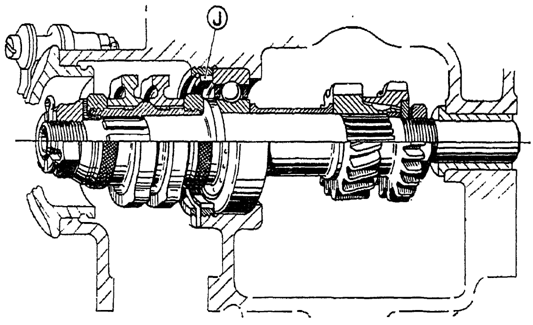
When screwing up gland nut do not use any tools.

When fitting a new liquid pump packing-gland the gland nut should not be overtightened in the first place. Overtightening would do more harm than good in effecting a sound joint, as it would damage the packing and necessitates starting over again with a new one. The gland nut in any case should be tightened up by hand.

Screw up lubricator " K " after refilling with grease.

The rotor end clearance is determined by thrust plug " H ". If

necessary, the gland housing "M" should be removed by unscrewing six countersunk retaining screws inside the top casing "N". A paper joint is between the two faces and should not restrict lubrication passages "O".



33.—FUEL PUMP AND GUN GEAR DRIVES.

Lower Vertical Drive (see Fig. 32). Detach cooling liquid pump carrier-bracket "A" with grooved oil stand-pipe "B". Unscrew nut "D" from end of shaft and tap off gears "E" with soft metal drift. Remove locking wire and upper housing-nut "C" and withdraw shaft and bearing downwards. The serrated liquid pump drive-spindle should be withdrawn after removing spring circlip and unscrewing nut "H".

Examine all gear wheels and ball bearings for wear, and the oil stand-pipe and carrier-bracket for cracks.

If the grooved oil stand-pipe has to be renewed take out the spring circlip and nut "C". When assembling see that the washer is in place.

Fuel Pump and Gun Gear Drives (see Fig. 33). Extract split pin, unscrew nut and slide off gun gear cams complete. Gears and ball bearings should then be tapped out after unscrewing retaining nut "J". Use special extractor for parting gears as shown in Fig. 34.

Examine all parts for wear and fit of bearings in casing.

Wheel Case Reassembly. For this complex unit the order of assembling is important. It is as follows :—

Fit the lower camshaft drive. Fit distance piece, two keys, magneto drive-gear, tighten up nut "M" and add cotter securing nut (left-hand thread).

Replace bevel roller-bearing and housing-nut and washers.

Replace magneto drive-shaft.

Replace gun control-shaft complete with gears and ball bearings.

Refit lower vertical shaft, replace gears "E", retaining nut "D", and cooling liquid-pump bracket. See that spline-shaft driving liquid pump is in place.

Replace hand-starter shaft.

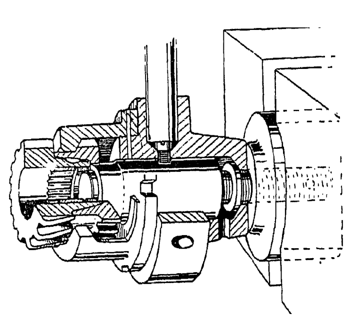


Fig. 34.—SEPARATING FUEL PUMP AND GUN GEAR DRIVES.

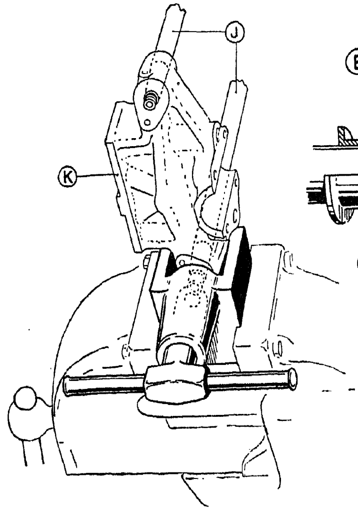


Fig. 35.—SEPARATING ROCKER SHAFTS FROM BRACKETS.

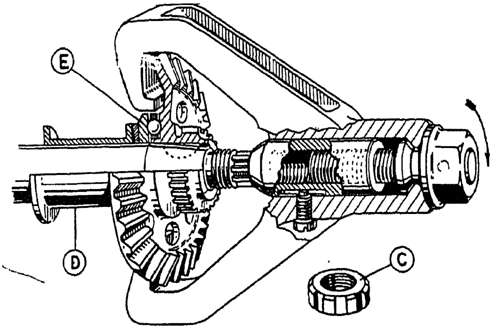


Fig. 36.—WITHDRAWING CAMSHAFT BEVEL WHEEL.

Refit oil-pump idler gear.

Replace lower parts of upper camshaft-drive units. The meshing of the gears is very important, and the units should be replaced in their original positions as marked.

Cylinder Blocks

Rocker Covers. Examine for soundness and " truth " on faces.

Camshaft and Rocker Mechanism. It will be remembered that this minor assembly was lifted off when the engine was dismantled. Remove front brackets and rockers from the assembly, unscrew all bearing-cap retaining nuts, remove bearing caps and upper halves of split bearings. Remove camshaft. Replace all parts except the camshaft. All distance washers should be labelled for reassembly. Slacken the clamping screws of the locating clips on the inlet rocker-shaft and from the front end slide off the various brackets, rockers and distance pieces (see Fig. 37).

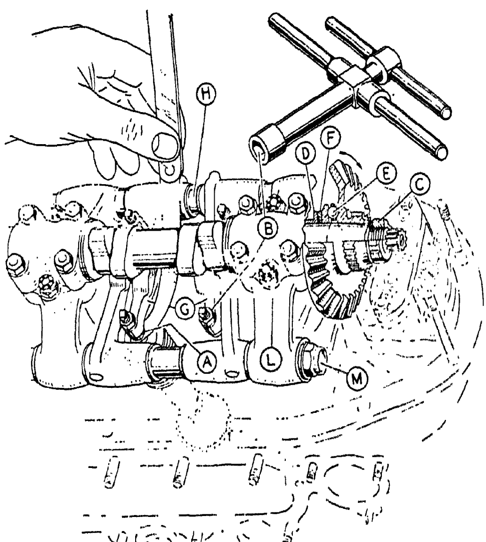


Fig. 37.—PART VIEW OF ROCKERS AND CAMSHAFT.

Remove from rear end caps of rocker shafts, and with special tool extract the spindle from rear bracket (see Fig. 35).

Remove nut and extract bevel wheel from camshaft (see Fig. 36).

Check teeth bore of bevel and fit of key.

Slight "picking up" in bore should be corrected. If a new bevel is fitted a 90 per cent. marking between shaft and wheel should be obtained and a new key fitted.

Remove thrust journal - bearings and adjusting washer, also identify.

Check camshaft bearings for wear and shaft for truth. Examine cams for wear. These surfaces cannot be touched up, for any wear the shaft should be renewed as a whole. New bearings should be fitted without reaming.

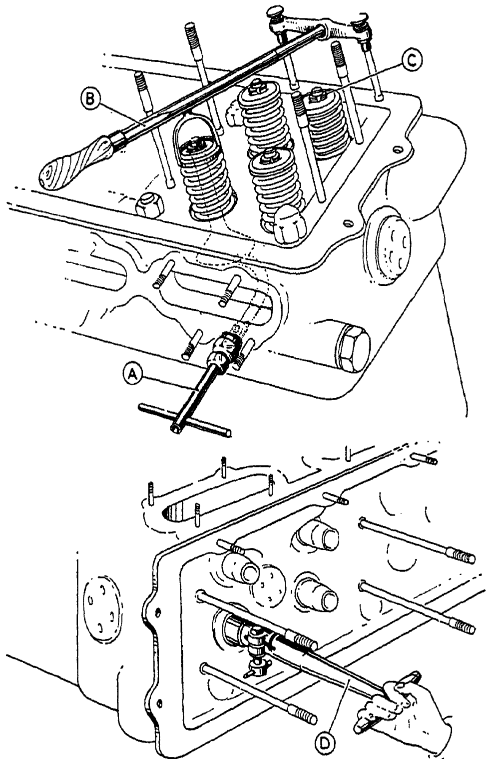


Fig. 38.—VALVE REMOVAL TOOLS.

Check bed-rings of rocker shafts and examine for wear.

Check tappet screws and pads of cam-operated rockers ; a badly marked screw or pad should be renewed.

Examine rockers for bending, and bores of rocker bushes for wear.

When Assembling. Fit keys in rocker shafts and fit to rear camshaft-bracket (note inlet and exhaust shafts are not interchangeable). Secure with retaining caps. Fit rockers and brackets in correct order. Fit adjusting washer over rear end of camshaft. Fit rear bearing, second adjusting washer, and rear race of thrust bearing. Fit key, thrust bearing and mount camshaft bevel. Fit lower halves of bearings in intermediate brackets, slide front bearing in position, position camshafts.

Note. Care must be taken to fit camshafts in their correct sides. Fit caps and retaining nuts. Final adjustments and clearances should be made during assembly of the cylinder blocks.

Valves and Valve Springs (see Fig. 38). Insert special tool "A"

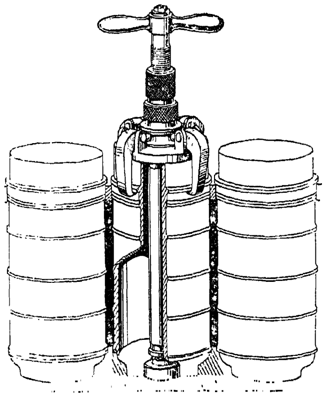


Fig. 39.—EXTRACTING CYLINDER LINER.

through an exhaust side ignition plug-hole, when valve retainer can be locked beneath any one of the four valves in that cylinder.

Attach special valve spring compressing tool " B " to long rocker cover-studs. When so arranged pressure may be applied to any valve spring in that cylinder.

Remove conical retaining washers " C ", valve-spring washers, springs and valves. Identify. Valves, cotters and valve ports are marked for assembly.

A valve should be renewed if its face is distorted, pitted or burnt to such an extent that a reasonable amount of lapping or grinding fails to restore the face. The stems should also be checked for distortion, and ends for wear.

Providing that suitable machinery is available the valve faces should be ground to gauge within the tolerances laid down.

Valve grinding is usually performed with all cylinder-liners removed and block mounted on its side.

The inlet valves should be ground into their corresponding seats with a special tool " D ", as shown, using a good fine grinding paste, smeared on valve face only.

The sodium-cooled exhaust valves are not ground into the nickel

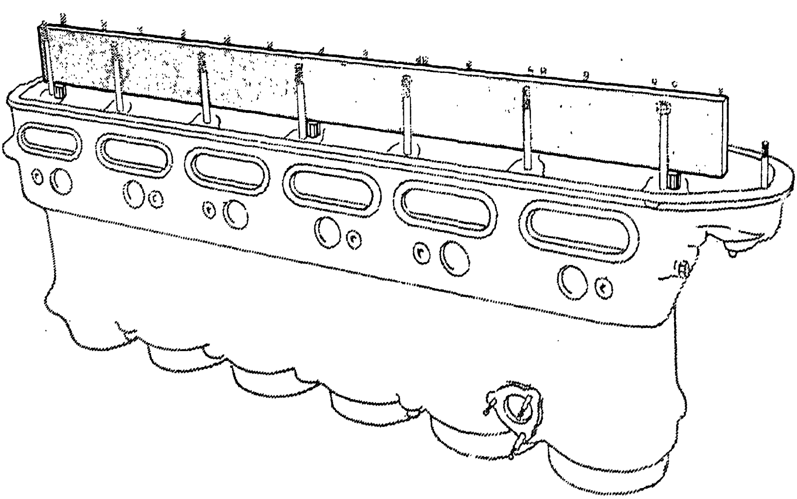


Fig. 40.—BOWING TEST ON CYLINDER BLOCK.

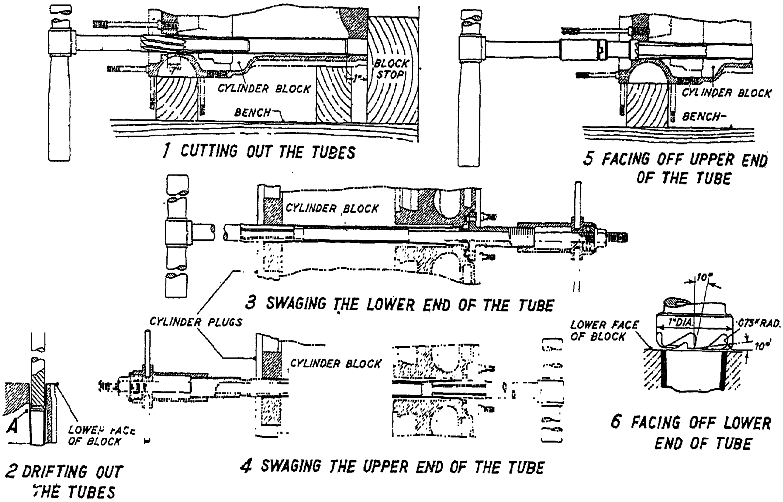


Fig. 41.—REMOVING AND REPLACING GUARD TUBES.

chrome manganese seats. The "bearing," however, should be tested as being correct.

Check valve springs for loading and chalk-test for cracks.

Extracting Cylinder Liner (see Fig. 39). Immerse blocks in water heated to approximately 70° C. for 5 minutes, and with special extractor

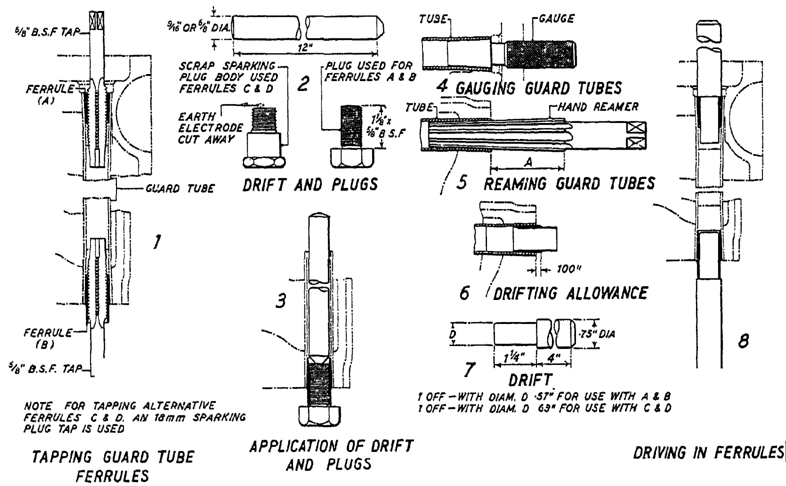


Fig. 41A.—REMOVING AND REPLACING GUARD TUBE FERRULES.

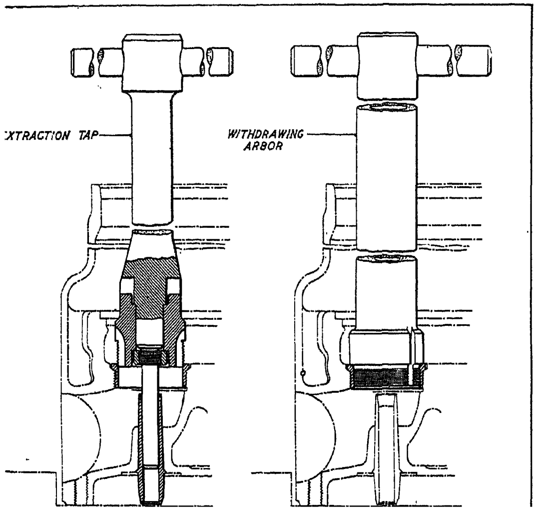


Fig. 42.—WITHDRAWING VALVE SEATS.

remove cylinder liner (see Fig. 39). These liners are delicate, and should be suitably stored. Liners are identified.

Remove upper joint rings and identify.

Examine casting for soundness and corrosive action, paying particular attention to all parts of the combustion head and using the chalk test. Seatings, joint rings and top of liners should be examined together for any effects of water leaks.

Inspect studs, sparking plug adaptors and valve seats.

Check block for bowing.

Set block up on a surface table and using suitable distance pieces (as shown in Fig. 40), such as rollers from roller bearings, place one on each end camshaft-bracket facing, and one in the centre. If block is true the straight-edge will bear equally on all rollers, if bowed either the centre or one of the ends will be clear and the error is measured by applying feeler gauges. Since the cylinder seating for the liner is delicate it is advisable to

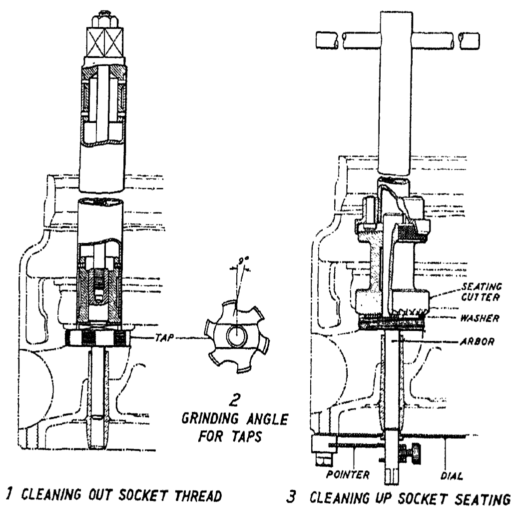


Fig. 43A.—INSERTING NEW VALVE SEATS.

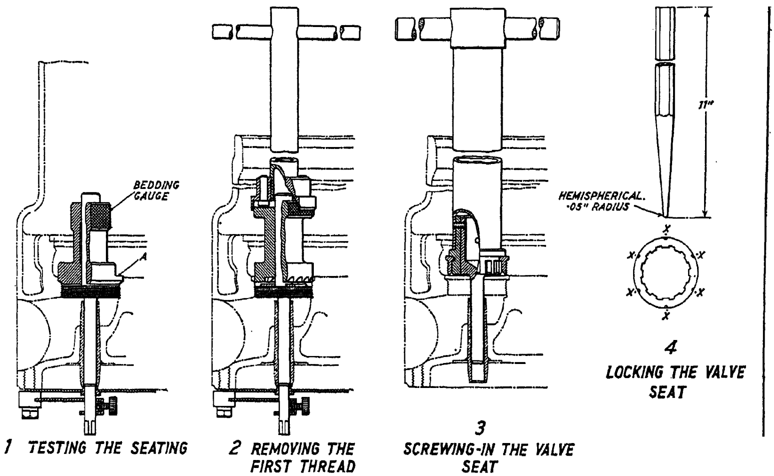


Fig. 43B.—LOCKING VALVE SEAT.

place old joint-rings on all seatings to remain in position until block is ready for fitting of liners.

Inspect cylinder stud-guard tubes, and remove any defective tubes by using the hand tools as shown in Figs. 41 and 41A.

These tubes are readily attacked by corrosive action, and for any pitting or defects in the plating on the tubes renewal should be made.

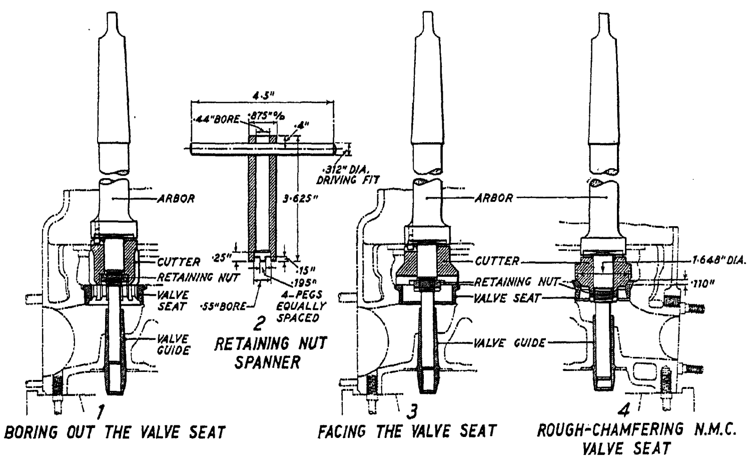


Fig. 44.—MACHINING VALVE SEATS.

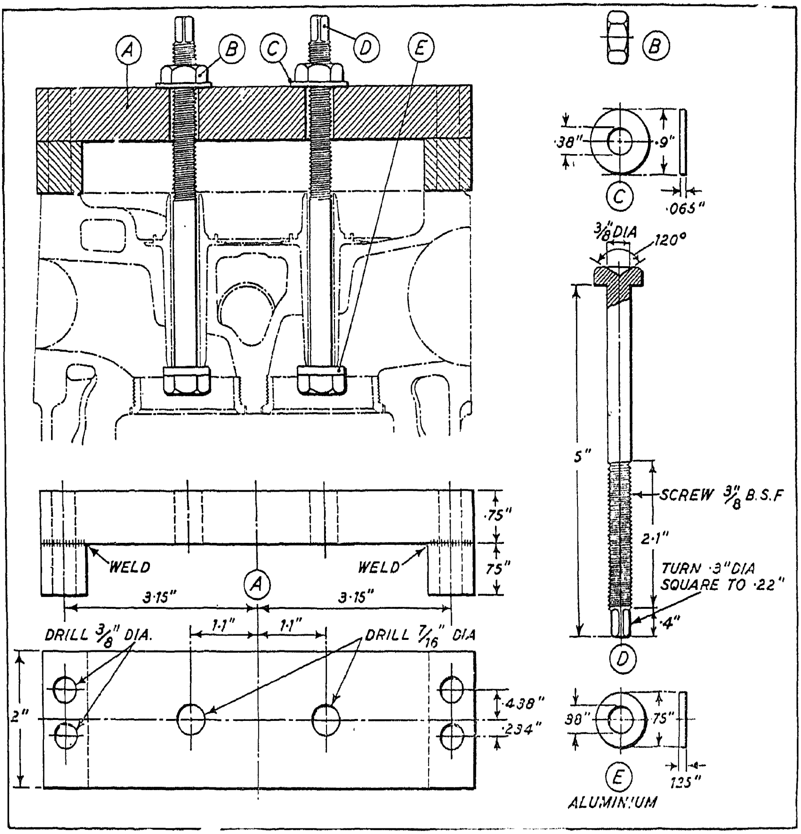


Fig. 45.—REMOVING VALVE GUIDES.

To remove any defective valve seats tap the valve-seat bores to take the special extractor (see Fig. 42).

Heat the block to 128° F. in a bath or oven for at least 30 minutes.

Remove block and extract defective seats.

Clean up sockets to receive new seats.

Standard oversize taps should be used to restore correct thread form.

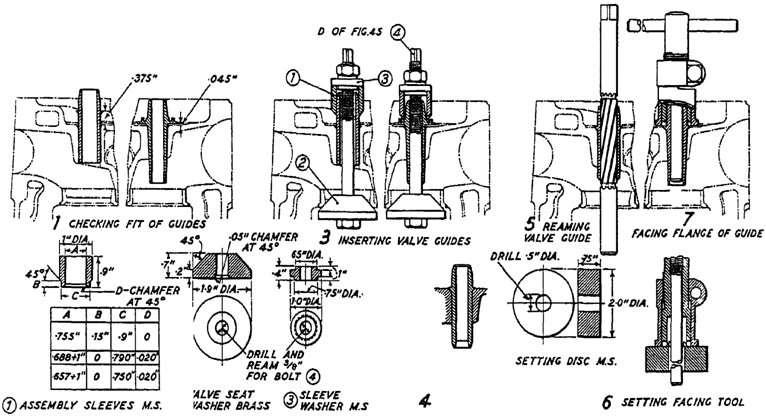
Special angle cutters should be used to clean up seating of the sockets.

Bedding gauges should be used to test the seating with a marking medium.

The application of these tools is such that all operations are concentric to the valve guide as shown in Fig. 43.

The new seat, by hand operation only, should enter the socket $1\frac{1}{2}$ to 2 turns only.

After the new seats have been selected, label them for quick identification on fitting.



A	B	C	D
·755"	·15"	·9"	0
·688+1"	0	·790"	·020"
·657+1"	0	·750"	·020"

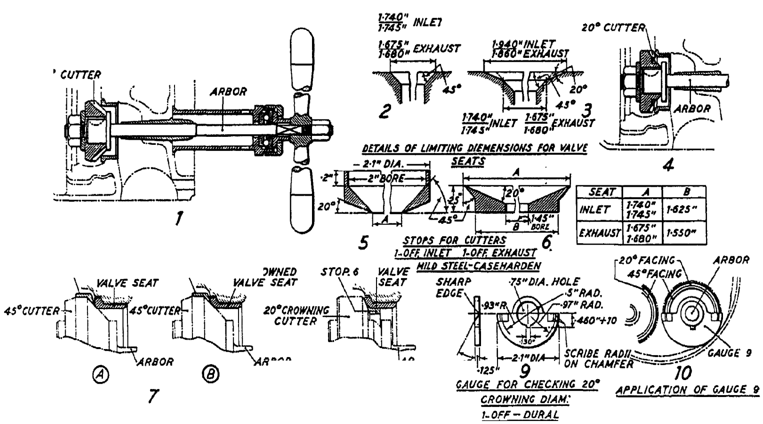
Fig. 46.—FITTING NEW VALVE GUIDES.

For fitting, heat block in a bath or oven to 280° F. for at least 30 minutes.

Remove block and fit new seats in their respective sockets, using a special spanner to take the internal splines (see Fig. 43). Screw down firmly by the double-handled effort of one man, but do not use tubing to increase leverage.

Lock seats (see Fig. 43).

With the block on its assembly stand and clamped to a table, bore seatings to size, as shown in Fig. 44.



SEAT	A	B
INLET	1·740" / 1·745"	1·625"
EXHAUST	1·675" / 1·680"	1·550"

Fig. 47.—HAND CUTTERING VALVE SEATS.

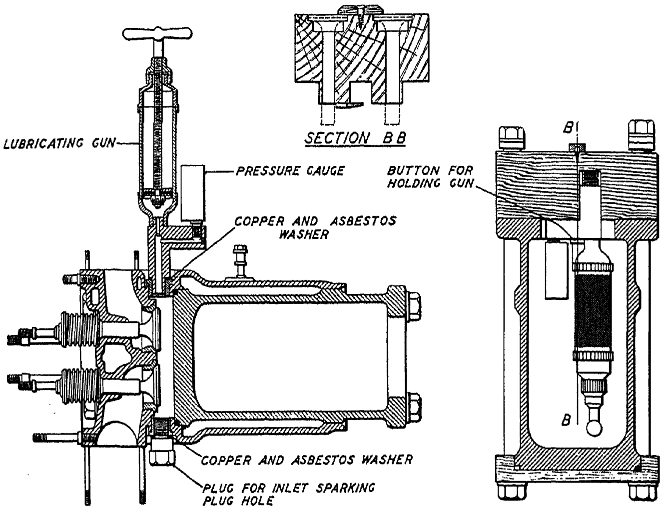


Fig. 48.—HYDRAULICALLY TESTING VALVE SEATS.

No cutting lubricant is necessary for the bronze seats, but for the nickel chrome manganese seats use lard oil.

Face seat with special cutter flush with casting, and rough chamfer, leaving 0·010 in. for use of hand tools (see Fig. 44).

Check valve guide-bores with "GO" and "NOT GO" gauges, and extract those which are unserviceable (see Fig. 45).

To fit new guides, heat block as previously described, tallow the guide and, using a suitable draw bolt, fit the guide.

Ream valve guides and check with plug gauges (see Fig. 46).

Hand cutter the valve seats, as shown in Fig. 47.

Fit new cylinder stud-guard tubes, these are already expanded at one end when received; this end is fitted to the lower face. The operations are shown in Fig. 41. Do not fit guard tube ferrules at this stage.

All new valve seats must be tested for leakage; this is done hydraulically to a pressure of 600 lbs. per square inch, as shown in Fig. 48.

The apparatus comprises a strongly-flanged liner having a robust crown and seating to take a rubber washer in lieu of the aluminium top-joint ring, and is held in place by four long bolts and nuts with suitable washers.

Bronze valve seats are closed off, using their normal valves, but on nickel chrome seats dummy valves should be used.

The inlet sparking-plug adaptor and gas starter connection are blanked off, and branch piece carrying a lubricating gun and pressure gauge is fitted to the exhaust side.

When the assembly is complete, as in Fig. 48, lay block on the inlet

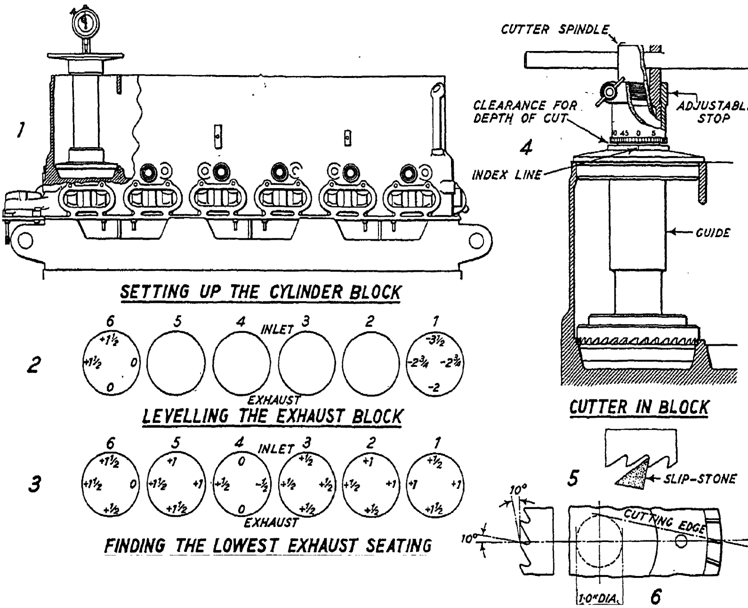


Fig. 49.—LEVELLING SEATINGS FOR CYLINDER LINERS.

side, unscrew top of gun and remove plunger, and fill with water to which a little special compound has been added to give the water a milky appearance and to dispel trapped air and bubbles. Replace plunger and top of gun, and screw in plunger until a pressure of 600 lbs. per square inch is obtained for 3 minutes. A faulty joint between a valve seat and cylinder block will be shown by leakage of the test fluid through the valve ports ; its milky colour will assist in its detection.

Cylinder Liners. These are marked for assembly, and bear the letter " S " showing the distance between the upper and lower faces, thus " S " is a standard liner. S − 15 indicates that 0·015 in. of metal has been removed from the top face.

Remove base gland and spring ring, inspect spring ring for corrosive action ; check loading :—

Free depth . . .	0·273 in.
26 lbs. loading . . .	0·250 in.

Inspect for corrosion above the recess for rubber base joint-rings and edge of upper seat. Check upper seat for pitting. Make dimensional checks of the bore as called for in Fits and Clearances.

If the upper seat requires refacing, the height should be determined and the skirt re-marked showing the amount below standard size.

The upper seatings of all liners should be lapped, a cast-iron block

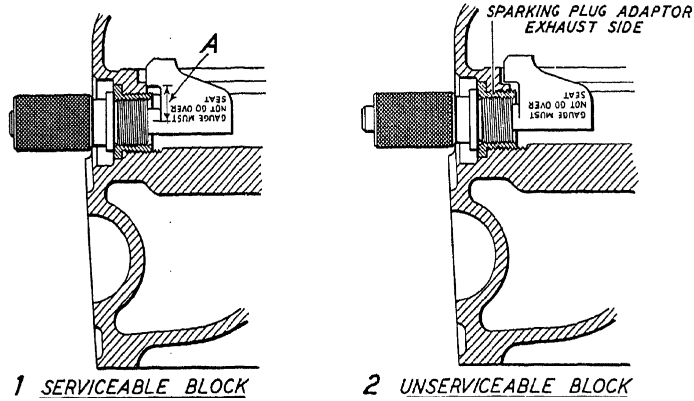


Fig. 50.—REJECTION GAUGE.

machined to take the seat is necessary, and fine compound should be used as the lapping medium.

Check all liners to see that the upper and lower faces are parallel.

Select a set of liners to the same dimension, *i.e.*, S − 10, low limit S − 9, high limit S − 11.

Cylinder Head Joint Facings (see Fig. 49). The reconditioning of these facings calls for considerable skill by hand, and irrespective of the permissible bowing allowed, the finished faces should be within the specified limits.

Invert block and place on a pair of adjustable stands on surface table. Scribe with a pencil the outline of the base of the stand on the surface table, this will enable location to be reproduced should the block be accidentally moved; the adjustable jacking points should be of equal height.

Using the special height gauge, set up the block so that the two ends seating are parallel or as nearly parallel as possible with the surface table. The height gauge consists of a tubular centre portion with a flange either end, which are in turn secured by taper pegs. One flange abuts the recessed facing for the cylinder liner, the other acts as a register for the dial test-indicator used in conjunction with the scribing block.

Any rocking of the block must be eliminated. This can be checked by bearing down on one corner and then on the one diagonally opposite, noting any change of reading on the dial test-indicator.

After the block has been levelled up, find the lowest seating. This is done with the special height gauge. This depth should be measured with a depth micrometer, and is taken from the lower face of the block

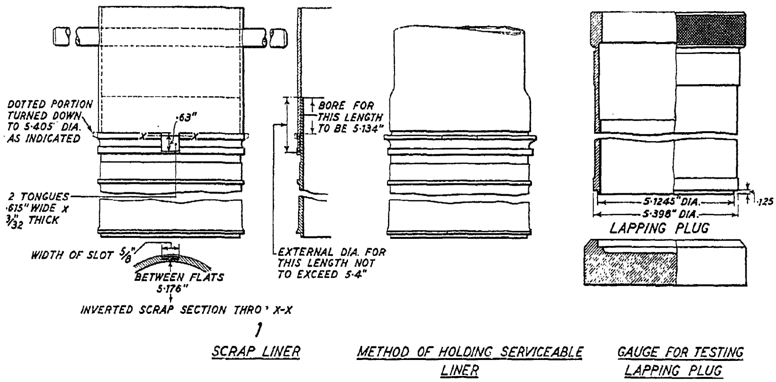


Fig. 51.—LAPPING TOOLS.

to the head joint facing. This dimension on a new block is 7·250 in. ± 0·002 in. Record the dimension.

See that the special cutter used for refacing is perfectly sharp and the teeth free from oil. Insert the cutter into the cylinder, the head seating of which is to be levelled, and be careful not to disturb the setting of the block on the surface table.

Gently lower the cutter until it abuts the face, slack off adjustable stop and reset to the amount required to clean up the seat. This should be as little as possible. Remove cutter and brush off cuttings through valve ports and recheck the seat, using the height gauge as previously described. This dial test-indicator should be loaded to the extent of approximately 0·005 in., and when bearing on the flange the pillar should be lightly tapped with the fingers to relieve any sluggishness of the indicator. It is essential that the scribing block is of very robust construction to ensure positive readings; the ordinary scribing block is unsuitable.

Cleanliness cannot be over-emphasised when using the surface table.

After the lowest seating has been cut use the special hook gauge to determine if the amount of metal removed is beyond the limit allowed; the gauge is used through the exhaust sparking-plug adaptor.

Should the hook of the gauge pass over the seating for the liner the block must be rejected (see Fig. 50).

Continue to reface the remaining five seatings to the same level as the already cuttered lowest seating.

Lap the liner to its appropriate seatings, using turkey stone powder (230 mesh) mixed with mineral oil; a bedding of 100 per cent. must be obtained (see Fig. 51).

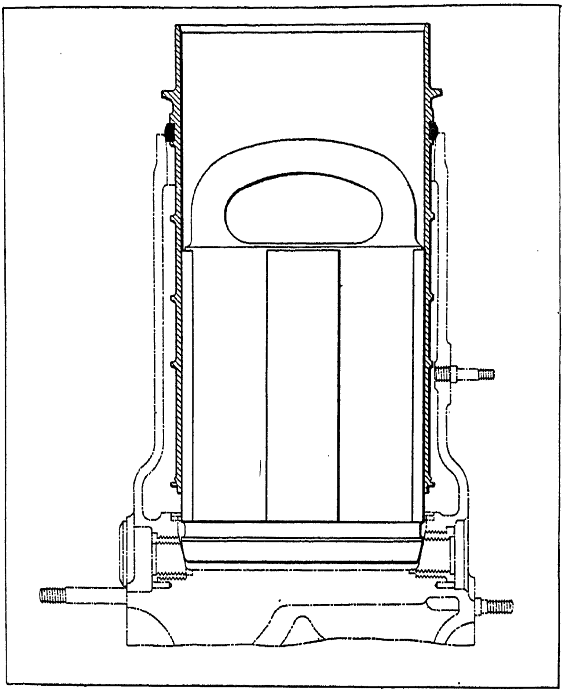


Fig. 52.—ASSEMBLING TOOL.

Remove all traces of the turkey powder from cylinder block and liner. This should be done with a brush dipped in petrol, cleaning finally with a clean soft rag.

To find joint-ring thickness :—

A. With a depth micrometer measure the distance from the lower face to the seating for cylinder liner.

B. Measure the distance between the upper and lower faces of the cylinder liner.

Proceed as in following example :—

Depth A. is 7·265 in. New 7·250 in.
Height B. is 7·415 in. New 7·425 in.

(*Note.* Liner to size of 7·415 in. should be marked S — 10.)

Therefore 0·015 in. of metal has been removed from block and 0·010 in. from liner, a total of 0·025 in.

Since the thickness of the standard joint-ring is 0·080 in., and there is 0·025 in. to be made up, the joint-ring thickness should be 0·105 in.

Lap joint-rings and check alignment.

With liners and rings in place, and using the special flanged ring gauge (see Fig. 49) the maximum mal-alignment permissible is 0·0005 in., otherwise further lapping of the joint-rings should be carried out.

When the correct alignment has been obtained withdraw liner and joint-rings, keeping them identified to their relative cylinders.

When assembling smear rubber sealing-ring with glycerine and pass overhead end of liner into its appropriate groove, fit split gland-ring and spring-rings.

See that all head joints are clean, fit thickness joint-rings, and using the special pilot (Fig. 52) and noting that the marking " E " on the

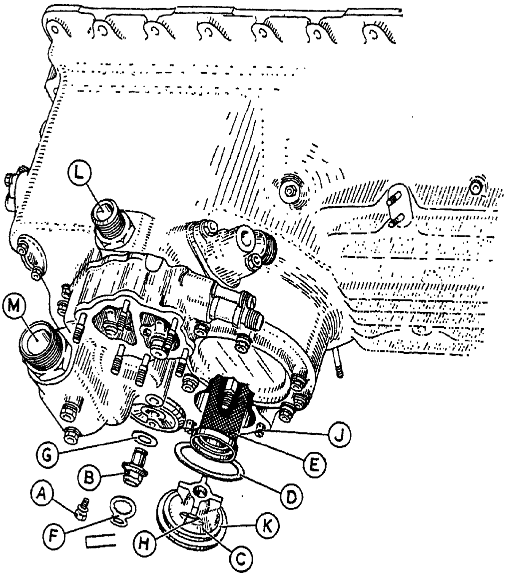


Fig. 53 (*right*).—REMOVING CRANKCASE OIL FILTERS.

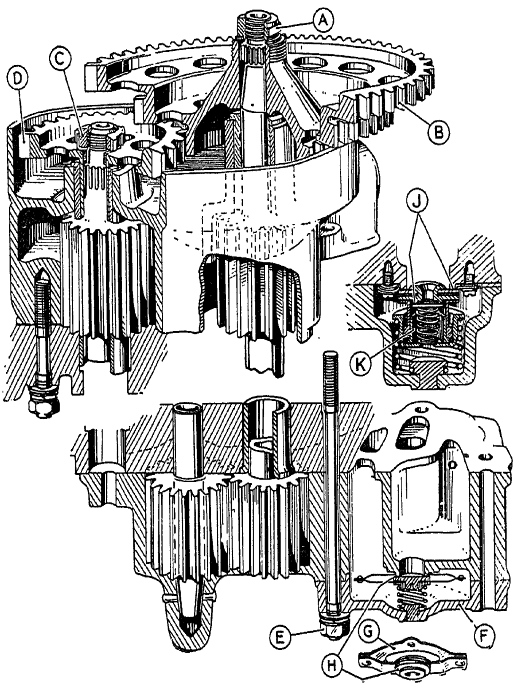


Fig. 54 (*left*).—OIL PUMPS AND RELIEF VALVES.

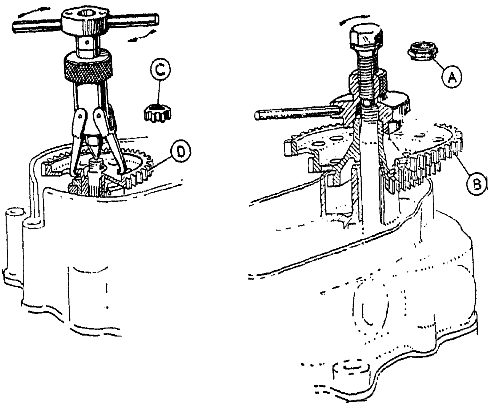


Fig. 55.—REMOVING OIL PUMP GEARS.

liners coincides with the exhaust side, assemble the liners using a reasonable pressure.

The guard-tube ferrules should be fitted at this stage (see Fig. 41A).

See that all the lower faces are clean. Fit a transportation stand over the block to engage the cylinder liners. Smear threads of holding-down bolts with tallow and fit nuts and tighten, but do not over-tension.

Note. The face of the transportation stand should be checked at intervals for correctness with the special surface plate.

To Air Test the Block. Blank off cooling liquid entry and outlet ports; one should be fitted with an ordinary motor car tyre-valve; couple this to a foot pump and obtain 20 lbs. per square inch pressure. Immerse block in a tank of hot water, and bring temperature up to 70° C. and pressure to 30 lbs. per square inch for 20 minutes. Check head joints, guard-tube ferrules, valve seats, core plugs, sparking-plug adaptors and studs, etc., for leakage. Any leakage is shown by air bubbles. Remove block and dry-off thoroughly.

Fit valves and springs (see Fig. 38). Note that assembly markings coincide.

Fit upper camshaft drive.

Fit camshaft mechanism and tachometer drive to "B" side.

Adjusting backlash of bevel wheels with adjusting washers "F" (Fig. 37) if adjustment is required.

Lock lower part of upper camshaft drive.

Check location and side clearance of rockers and adjust locating clips.

Fit camshaft cover temporarily.

Gas Starter (if fitted). After dismantling, check the following for wear:—

Bore of distributor casing bushes.

Diameter and end float of rotor shaft.

Backlash between splines and splineways at each end of coupling.

Assemble and attach temporarily to cylinder block.

Engine Speed Indicator Drive. Dismantle and check the following for wear:—

Bore in housing and bush.

Diameter of drive gear boss and shaft.

End float.

Backlash between gears.
The casing should be examined for wear.
Assemble the unit and attach temporarily to cylinder block.

Pistons

With piston rings removed, all of which should be renewed, examine pistons for wear, burrs and loose ring stops. The chalk test is most useful for this work. Renew for any defect.

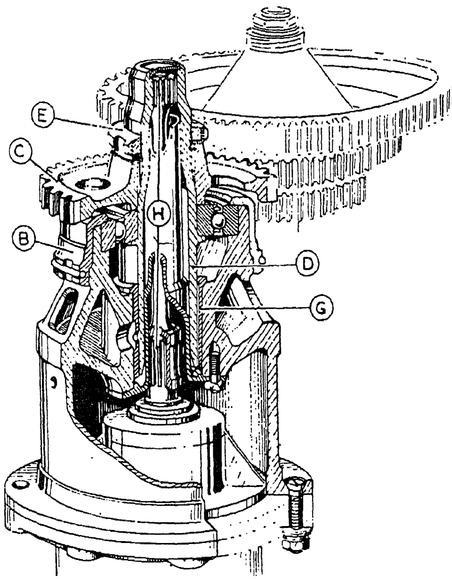


Fig. 56.—CRANKCASE AIR COMPRESSOR DRIVE.

Crankcase Lower Half, Oil Pumps and Compressor

For arrangement of oil filters see Fig. 53.

Take out locking-plate screw "A" and remove plate "F". Unscrew central cap-nut "B" and remove cap "C", joint washer "D", and filter "E". Repeat for second filter. The filter casings inside the crankcase are secured by two tapping screws "J", and the pipe from the front casing should be removed before detaching the casings. Washer "G" and nut "B" are retained in the cap by a wire staple threaded through holes "H". Examine the filters for any gauze defects.

The oil pumps and relief valves are illustrated in Fig. 54. To remove, bend tab washer and unscrew main-drive gear nut "A".

Note. The idler driving wheel should have been lifted out.

Attach a special tool and withdraw gear "B". Bend tab and remove nut "C" from smaller drive gear "D", and withdraw with a special tool.

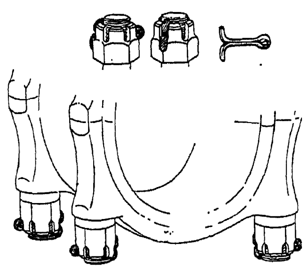


Fig. 57.—METHOD OF SPLIT PINNING CONNECTING-ROD BOLTS.

Unscrew six nuts "E" from relief-valve cover "F" (outside crankcase) and carefully remove cover and valves "G". Unscrew remaining nuts and remove pressure pump from the outside, and scavenge pumps from the inside of crankcase (see Fig. 55). The main drive spindle is integral with one of the scavenge pump gears.

Examine all gears and bearings for wear, and the relief valves and springs for correct-

ness. Particular attention should be paid to all working surfaces, which must be undisturbed, to ensure quick action and perfect bedding.

Examine the casting for soundness and the faces for " truth."

The order of assembly is the reverse of dismantling.

Low Pressure Air Compressor. The drive for this auxiliary unit when fitted is shown in Fig. 56.

To remove, unscrew compressor-drive cover retaining-nuts and detach drive unit and serrated spindle. Remove spring circlip from large serrated nut " B " and unscrew the nut. The drive gear " C ", ball bearing and shaft " D " can then be freed from the housing. Bend tab and serrated nut " E " from gear end and tap out shaft " D ". This will free gear and ball bearing.

The drive and unit if fitted when dismantled should be examined for wear, the unit tested for capacity, and the whole reassembled in the reverse order to dismantling.

Crankcase Upper Half, Crankshaft and Connecting Rods

Crankshaft. Remove all oil-sealing caps and examine for signs of irregular oil flow. Examine shaft for " truth," scoring of crankpins and main bearing journals, and surface disturbances. Examine driving flange and splines for spring drive. Note Fits and Clearances for fitting of oversize spindles in splines.

Regrinding may be carried out to the limits laid down, but care should be taken to avoid faces of crank webs with grinding wheel. The crankshaft journals should be highly polished. A leather strip and rouge may be used for this purpose. The sealing caps should be lapped to their respective journals before refitting.

Note. All joints, nuts, washers, etc., face rear of engine.

Connecting Rods. Examine for " truth," wear, and any surface disturbances.

Renew bearing shells and bolts.

The blocks should be jig-fitted to the rods, and the holes reamed to the exact size for correctly fitting bolts. The usual type of jig may be used for these operations.

When fitting connecting rods see all markings coincide. These commence from the front of the engine. Check that arrow on forked rod tallies with rotation, *i.e.*, forked-rod leads.

Test all rods for freedom. (Limits are stated in List of Fits and Clearances.)

When split-pinning nuts it is of vital importance that all split pins are a tight fit, and secured as in Fig. 57.

Renew small end-floating bushes and check float.

Upper Half Crankcase. Inspect for soundness and " truth " of all faces.

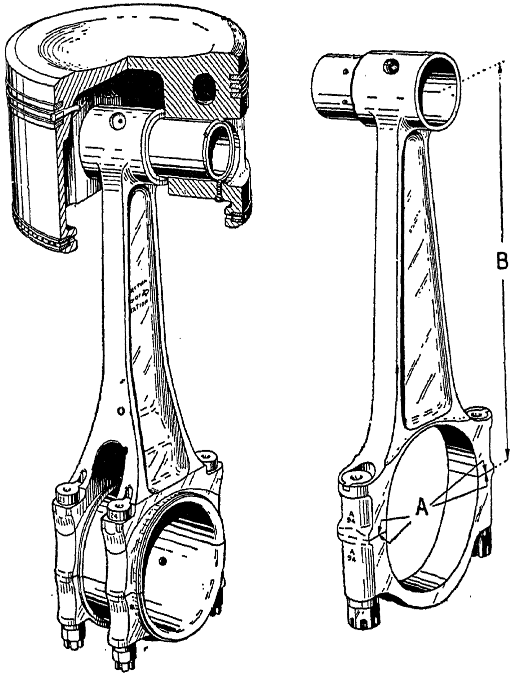


Fig. 58.—PISTON AND CONNECTING RODS.

Attention should be given particularly to the bearing webs, studs, feet and reduction gear-end, which should be chalk tested.

Fit a new set of main bearings, the fitting of which should be carefully carried out for both the bearing webs and the feet.

A boring jig of the usual design, giving a dead smooth surface, should be used for cutting the journal bores to the final dimension. No other operation should be required.

Assemble connecting rods and crankshaft in the crankcase and, using a suitable apparatus to connect up the journals, test the oiling system with the correct engine oil heated to a temperature of 50° C. and a pressure of at least 80 lbs. per square inch for 15 minutes, gently turning the crankshaft during the whole time.

Bearing leak should not be excessive, but it should be confirmed that oil reaches all crankshaft journals and big ends of both forked and plain connecting rods.

Observe that oil pipes and connections are free from leaks.

If the system is correct, lock the main bearing caps. Assemble the crankcase lower half minor assembly. This may be considered as the first stage of the erection.

Proceed as follows :—

ERECTION

Wheel Case. For the last operation the crankcase unit should be bolted to the engine cradle, and, as stated, may be considered as the first stage of erection. Place gasket over wheel-case retaining-studs and slide wheel case into position, rocking the lower vertical shaft until the idler wheel meshes with the oil-pump drive, fit spring washers and nuts.

Fitting Spring Drive Unit, Supercharger and Dynamo. Separate compound gear casing and remove gears. Place gasket over studs and

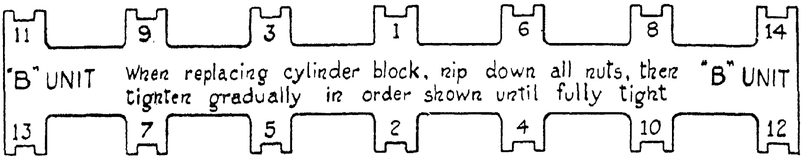


Fig. 59.—CYLINDER NUT TEMPLATE.

mount portion of gear case and spring drive. Secure by bolts "N" (Fig. 25). Place gasket over studs and mount compound gear casing, turning crankshaft or gear at rear of the spring drive until the master splines of crankshaft and spring-drive shaft mesh. Secure casing.

Pistons. Turn crankcase to bring either side cylinder block horizontal, and fit pistons for the cylinder block. The pistons are numbered for which rod they are to be fitted, and are fitted so that the top-ring stop faces the exhaust side. Fit gudgeon pins and retaining rings " F ".

Cylinder Blocks. Place Nos. 3 and 4 pistons to T.D.C. Fit bands for compressing piston rings around pistons Nos. 3 and 4.

Remove camshaft mechanism from cylinder block and place conveniently.

Remove block from transportation stand.

Note. It is safer to invert the block and lift stand clear.

Fit lifting plate to cylinder block (see Fig. 8).

Fit rubber sleeves over cylinder block retaining-studs.

Lower block over retaining-studs and enter Nos. 3 and 4 pistons.

Use bands for the scraper rings.

When Nos. 3 and 4 pistons have entered, fit bands to the remaining pistons and lower the block until all pistons have entered.

Note. Special narrow bands are required for the scraper rings of pistons for liners 1, 5, 2 and 6 when the liners are about to enter the crankcase.

Ensure that the lugs press the scraper rings into their grooves. This is a delicate operation as the scraper rings are fragile.

Press down the block on to its seatings.

Place the dogs over the intermediate holding-down studs, smear tallow on all threads and fit the nuts. The special clutch spanner should be used for this purpose. Correct rotation of tightening should be observed as shown in Fig. 59.

Fit the other cylinder block in a similar manner.

Smaller Assemblies. Fit cylinder cooling liquid pipes.

Place induction trunk between cylinder blocks and fit induction manifolds.

Draw induction trunk up to induction manifolds and secure.

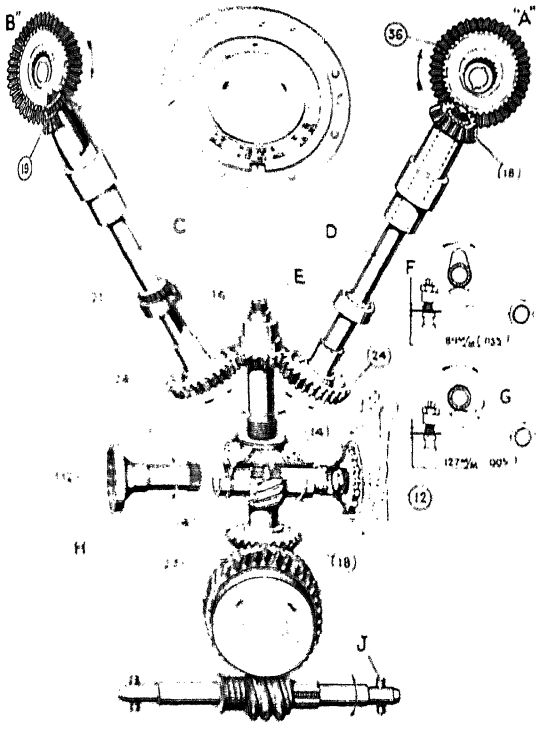
Fit camshaft mechanism.

Reduction Gear. Fit reduction gear, lifting gear by means of the special lifting tool (see Fig. 2).

Smear ends of coupling shaft with petroleum jelly and insert the smaller end into the driving pinion of the gear, noting that the etched lines coincide. Swing gear into position and slide over the studs, noting that the etched line on the larger end of the coupling mates with that on crankshaft driving flange.

Secure and fit oil-feed pipe.

Valve Timing. For the purpose of timing, these engines are provided with a timing disc, pointer and inspection plug "H" (Fig. 11) at the front end of the reduction-gear pinion immediately below the airscrew shaft.



DIAGRAMMATIC LAYOUT OF TIMING GEAR.

Fig. 60 shows diagrammatically the t gear layout as viewed from the rear of the engine. It also shows

(*a*) Timing disc, markings and pointer for setting, looking on the front of engine. (Shown for supercharged engines.)

(*b*) Serrated drive shafts and number of teeth at each end.

(*c*) Direction of rotation of shafts and

(*d*) Number of teeth on each gear

(*e*) Position of cams when

The camshafts are geared turn at half crankshaft speed and the magnetos at one and a half time

The vertical drive shaft "E" is geared to an extension from the crankshaft. Inclined shafts "C" and "D" transmit the drive through bevel gears to each camshaft marked "A" unit (right-hand side) and "B" unit (left-hand side), their engagement being by serrations at each end.

The left-hand "B" side shaft "C" is shown disengaged to allow camshaft to be turned independently of as when timing the "B1" cylinder.

Set inlet tappets of 6A and 1B to 0·035 in. clearances as shown at " F ".

Remove timing plug from reduction gear and turn crankshaft in the direction of rotation until A6 I.O. is opposite pointer.

Turn camshaft in the direction of rotation until inlet valves of No. 6A are just about to open as shown at " G ".

Turn upper camshaft drive " D " to such a position that it engages with its lower part, using the serrated vernier adjustment provided by the 19 and 21 serrations at upper and lower ends (see Fig. 60).

Replace and secure retaining cover " C " of Fig. 7.

Set all tappets of this block to 0·020 in. clearance.

Turn crankshaft until B1 I.O. is opposite timing pointer and adjust the timing of this block as previously described. Finally, set tappets to 0·020 in. clearance as before.

Ignition Timing. Turn crankshaft in the direction of rotation until the line marked A6, MA is opposite the pointer (see Fig. 60) with all valves closed in the A6 cylinder.

Remove contact-breaker cover from " B " side magneto and fully advance the contact-breaker mechanism.

Fit serrated end of shaft " H " (Fig. 60) to flange.

Set distributor pointer " E " (Fig. 17) to serve A6 cylinder, *i.e.*, No. 12. See Fig. 5, Vol. II., page 273, with the contact-breaker on the point of opening.

Now connect other end of serrated shaft " H " without movement of any of the parts already positioned.

A vernier is provided by the shaft " M " having 11 and 12 serrations at either end. Secure magneto and check the timing.

Note. To check the timing use a lamp and battery in the usual manner.

Repeat for timing the other magneto, using B1 MA opposite the pointer.

Smaller Assemblies. Fit high-tension leads and plug fittings in correct sequence.

Fit priming and drain pipes.

Fit cooling liquid outlet pipes.

Fit rocker covers, engine speed indicator drive and gas starter, if used.

Supercharger and Carburetter Unit. When fitting the unit the following operations should be carried out :—

Oil bushes for compound gear wheels, and fit bushes and wheels.

Fit the oil pipes connecting the supercharger gears, wheel case and rotor shaft rear-bearing. On the supercharger gear pipe connect a hand-operated pump, and closing end of the pipe to rotor shaft rear-bearing with a finger, pump clean oil into the system until it leaks from the rear bushes of the compound gears. Remove hand-operated pump. Fit oil pipe for high pressure supply to fuel pump gland.

Slacken gland nut at rear end of induction trunk. Remove nut,

washer and packing ring from supercharger gland and place them over end of junction piece which is fitted in rear end of trunk.

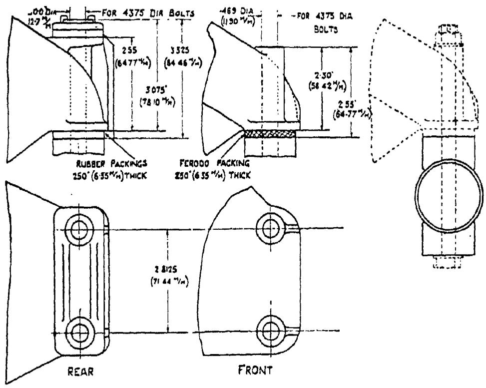


Fig. 61.—ENGINE FEET.

Place washer over the studs of the gear casing and lift supercharger unit into location. Several attempts may be necessary to engage rotor and compound gears. Secure the unit.

Fit rubber seating-ring into the volute gland. Enter gland ring and secure the nut, and tighten gland nut at rear end of induction trunk.

Connect cooling liquid feed-pipes between "A" side outlet and carburetter and return pipes between carburetter and pump. Fit oil pipe to supercharger rotor shaft rear-bearing.

Connect up ignition controls.

Fit volute drain pipes to priming system, and the lower union to supercharger casing, which is in turn connected to the venturi on the air intake.

Water Test of the Complete Engine. Blank off cooling liquid outlet, and with a suitable apparatus pump hot water into engine through the cooling liquid pump inlet; raise pressure to 8 lbs. per square inch. Check all joints for leaks.

Priming Engine with Oil. Using a suitable apparatus with an oil pipe connection to the high-pressure pump inlet, pump hot oil at a temperature of 50° C. into engine and raise pressure to 65 lbs. per square inch. Turn engine slowly for 5 or 6 turns, repeat at intervals of 3 minutes until oil issues from No. 1 A and B camshaft rockers. Check all pipes and investigate any leakages.

The engine is now ready for testing.

TESTING

The overhauled or reconditioned engine having been erected and passed to the test bench, should be subjected to the following tests :—

1. After all connections are made, a motoring * test of not less than 30 minutes followed by one or two short interval runs to ensure that all systems are functioning properly, the valve and ignition timings are

* The engine driven, NOT driving.

correct and the main mixture supply and fuel levers are correctly set to the throttle openings.

2. A non-stop run of not less than 30 minutes' duration at the maximum cruising conditions as for level flight, except for the last 5 minutes when the engine should be run at the r.p.m. and boost for maximum climbing conditions.

3. A 5-minute check test at the maximum level flight and take-off conditions at sea level, followed by a rated altitude power curve of at least five points.

The requirements to comply with the above tests for the engine being described are to be found under leading particulars in Vol. II., page 265.

The power developed under the maximum take-off conditions at sea level, and at the international r.p.m. on the rated altitude power curve, corrected to standard conditions in accordance with this Schedule must be within the specified permissible tolerance on the "type" * engine performance.

INSTALLATION

As it is not part of this article, which deals with the engine only, it may be assumed that the remainder of the installation, viz.: fuel, lubrication and cooling liquid system, have been dismantled, overhauled and replaced.

The engine, therefore, is slung to rest on its feet, which are of the flat type, with packings inserted between the feet and the bearer; Ferodo packings being used under the front feet and rubber packings both under and above the rear feet. Additionally, aluminium plates are used on top of the rubber packings above the rear feet (see Fig. 61).

The holding-down bolts are made secure, and the fuel, lubrication and cooling liquid systems are connected. Exhaust manifolds, if any, are fitted, ignition wiring, boost gauge, tachometer, main mixture supply lever and fuel controls are fitted, together with any auxiliary drives.

With fuel, lubrication and cooling liquid systems filled, taking all precautions against formation of air locks, the installation is ready for final adjustments as follows:—

Disconnect the pilot's manually-operated main mixture supply and fuel levers. For slow-running adjustments, "B", "C" and "D" (Fig. 18) and T. and V. (Fig. 24) apply. Slack stop "D" until butterfly throttles are fully closed.

Proceed as follows:—

Screw up stop "D" until it engages throttle lever. Continue turning for half one revolution of screw, then lock the latter.

* Type tests are those tests laid down by the Directorate of Technical Development of the British Air Ministry through which any engine must pass as a preliminary to a production order.

Place worm plug at " B " with its eccentric hole at the lowest point, that is, halfway over the throttle edge.

With adjusting key push down slow-running adjustment at " C " and screw down on to jet face (lightly).

Screw back the slow-running adjustment " C " one-quarter of a revolution.

With the engine at working temperature the remainder of the adjustment should be done on the slow-running worm at " B ", and it should be checked that the throttle can be closed suddenly from 1,200 to 1,400 r.p.m. back to idling speed without cutting out or erratic firing.

The idling speed should be between 600 and 800 r.p.m., and it is advisable to adjust slightly on the " strong " side.

If " cutting " occurs when opening up, screw down jet " C " very slightly.

For other running, first check the following :—

The independent movement of main throttles by control from boost regulator relay. Check this by holding lever " L " and moving relay lever " N ". Lever " F " should revolve in an opposite direction without reacting appreciably on lever " L ".

With the butterfly throttles against slow-running stop " D " the magnetos should be fully retarded. The relay piston should be at the full " in " position against plug stop.

The screw stop " P " is adjusted to determine the throttle take-off position, and point " A " should be screwed back so that the required movement is obtainable.

When lever " L " is fully advanced against stop " P ", the point " A " should depress mixture control valve 0·030 in. to 0·040 in.

" E " is the accelerator-pump lever, " K " and " M " the boost regulator change-over cock and cut-out controls respectively, and " Q " the differential box (corresponding to " L " Fig. 10, Vol. II., page 280). Be sure to couple up link with lever " K " of change-over cock in " upward " position as shown, and not downwards. Now connect up the pilot's manually-operated main mixture-supply lever to " L " and fuel-control lever to " O ", and set the gate of the quadrant to the full-throttle position (see page 276, Vol. II.).

The adjustment of the levers should be carried out with great care.

It is important to see that their movements do not in any way interfere with the movement of the engine controls connected thereto except to relay them to the correct quadrant positions.

Do not lock up the controls finally until the engine has been ground-tested (see page 484, Vol. II.) and found correct.

De-rating

These adjustments apply to the engine as described for the fully-rated boost. There are, however, conditions under which the makers

will authorise a lower rating. Such conditions are those where it is unnecessary to use the maximum working capacity of the engine for take-off, and where the aeroplane airborne may operate at a lower cruising speed. The amount of the de-rating is a question of consultation with the makers.

Generally, for the same operating conditions, an engine with a decreased boost rating will give a longer life before complete overhaul is necessary.

The decreasing of the fully-rated boost is effected by the screwing up of the aneroid unit in an anti-clockwise direction with the controls, relay piston and aneroid unit disconnected ; 12 to 15 serrations movement is equivalent to 0·5 lb. boost difference.

It should be understood that when setting the rated boost the automatic boost being controlled by an aneroid which varies by the barometric pressure (the same as the boost gauge), no allowance for static (ground setting) reading is necessary in this respect ; but the boost gauge should be checked for accuracy against the barometer of the day. To do this, observe the boost gauge reading when disconnected from the engine. This reading should be exactly the same as the barometer reading of the day. The accuracy of the boost gauge is most important.

Cooling Liquid System

When describing this system in Vol. II. (see page 284) a description of the diagram Fig. 11 was inadvertently omitted. It is as follows :—

A pump " A " circulates the liquid to radiator " B " and each cylinder block, returning to header tank " D " in the normal manner. In addition, a condenser " E " is provided. The condensate from this condenser is returned to the system by an injector " C " energised by the pump, thus when vaporisation occurs liquid is not lost to the system. The header tank " D " is not vented to atmosphere as in a normal cooling system, but connection is made to the condenser with a pipe of sufficient area to avoid any chance of excessive header-tank pressure. The condenser is vented through passage " H " to the base. The valves " F " and " G " are provided for conditions of inverted flight preventing the liquid draining back to the condenser, and allowing pressure to be released if generated at such flying conditions.

It is desired to thank Messrs. Rolls-Royce Ltd. for their kindness in allowing the printing of many figures shown throughout these articles.

NOTES ON THE INSPECTION OF METAL HULLS AND FLOATS

The following notes on the above subject are intended to indicate the attitude which should be taken by the inspector or ground engineer responsible for the maintenance of flying boats and seaplanes in service.

By R. H. Longe,

Works Manager, Saunders Roe Ltd.

THE duties of the inspector of metal hulls and floats will be rather different from those of the person inspecting or maintaining land-planes, owing to the nature of the material employed in the structure and the sphere in which it is operating.

The duralumin alloys in general use are made up in sheets, bars and tubes.

A special material is supplied in the form of sheet and is, in effect, duralumin with a thin coating of pure aluminium on either side.

This coating has a marked resistance to the corrosive action of salt water, and every endeavour should be made to maintain this coating intact, both during and after construction of the hull or float.

The keelson, or " backbone," of the hull or float is usually built up of duralumin sheet or strip, and anodised before the webs and angles are riveted together.

Additional protection is also given to the structure by brushing or spraying on three or more coats of a pigmented oil varnish.

Surface Corrosion

Salt water causes surface corrosion, which, in its initial stages, takes the form of minute blisters. If these are broken, a white powdery deposit will be found underneath, this being aluminium oxide. The region where this is first found is usually around rivet heads in the skin plating, and along the plate laps. This corrosion, around the rivet heads, is often due to the riveting gun or snap cutting through the aluminium coat on the alclad sheet, when the head is " hardened up."

Sometimes a plate will begin to corrode over its entire surface, and may be due to the fact that incorrect heat treatment has been given the plate after it has been formed or worked.

This material does not attain its correct strength unless this final heat treatment has been applied and will corrode rapidly if it has been annealed or softened to facilitate working, without giving it this final heat treatment.

Duralumin rivets are given final heat treatment before use, and must be used within two hours of quenching. If used after this period, they will be difficult to form and minute cracks will show up around the head and the shank, where corrosion has commenced.

Points on the structure where fittings are attached by means of bolts will also show early signs of corrosion if washers are not placed under the nuts, and so preventing them from damaging the protective coating.

Checking Corrosion on Hulls and Floats

The most effective method of checking corrosion on both hulls and floats in service is by regularly "hoseing" down the exterior of the structure with fresh water, preferably under a good pressure. Any time spent in so doing is amply compensated for by increased service.

As soon as corrosion is found, it should be removed and a new coat of protective varnish applied. An excess of varnish should be avoided as this will merely flake away again.

As often as possible, the seaplane or flying boat should be placed on its cradle and hauled up, taking care that the hull is supported under its frame, and so avoiding distortion of the planing bottom.

All main and bulkhead drains should then be opened and any accumulation of water allowed to drain away. The hose is then played on to the structure internally around the keelson and plating, at least as high up as the normal water line, working from the highest point on the hull down to the main step. When using the hose, the jet of water should be played into all corners and plate laps. If the washing down has to be done afloat, the sea water should first be pumped out by means of the bilge pump and then "swabbed" down with plenty of fresh water.

Waterways in frames, keelson, etc., should always be kept clear, to prevent the accumulation of sea water. Mild steel bolts, nuts, screws, etc., laying in the bilge are a fruitful source of corrosion, as also are items of marine equipment not correctly stowed.

Determining whether a Corroded Plate shall remain in Service

The inspector uses his discretion in allowing a corroded plate to continue in service. The extent of corrosion and its location will be the determining factors. For instance, corrosion in the region of a main plane or strut attachment fitting will be regarded as more serious than the same degree of corrosion in the centre of a plate aft of the main step.

As the plating of the hull or float is stressed, that is, contributes to the strength of the structure as a whole, any corrosion tends to reduce the strength of that unit. Once it has started, it must be removed and reprotected, afterwards being carefully watched. Although it may be removed from the surface, the corrosion tends to work along underneath the surface and will show again at another point. It will then reach the stage when the corroded material can be lifted off in flakes.

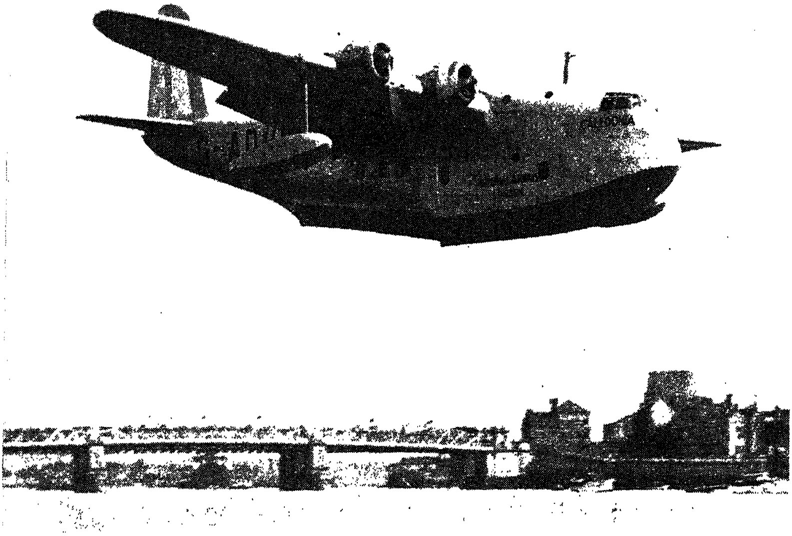


Fig. 1.—THE "CALEDONIA" EMPIRE FLYING BOAT.

The hull is of monocoque construction, covered with alclad sheeting. The wings are all-metal stressed skin construction, built on two main lift trusses of ordinary N-girder type.

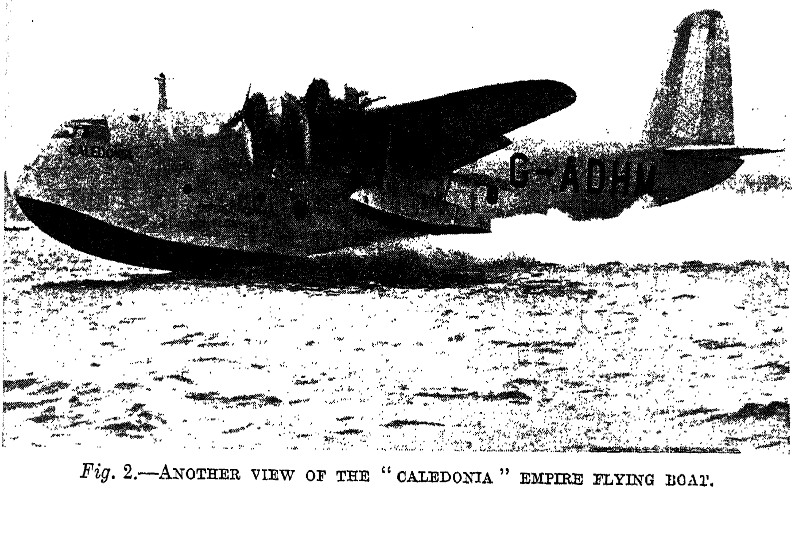


Fig. 2.—ANOTHER VIEW OF THE "CALEDONIA" EMPIRE FLYING BOAT.

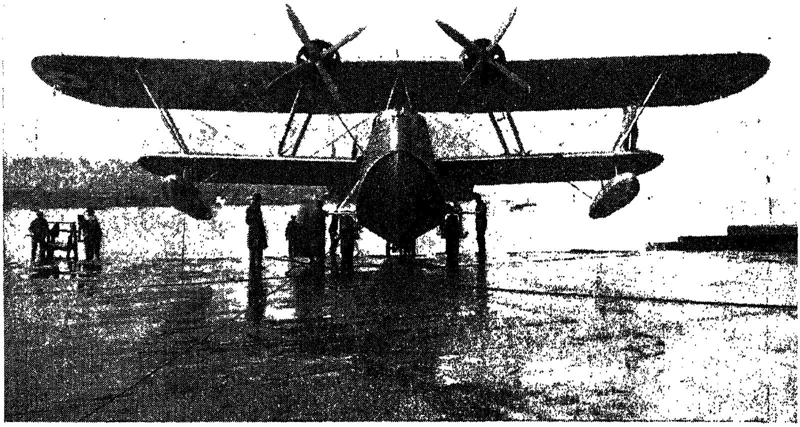


Fig. 3.—THE "SARO" LONDON FLYING BOAT.

The hull is of alclad. The planking is corrugated or fluted to avoid the use of riveted-on stringers.

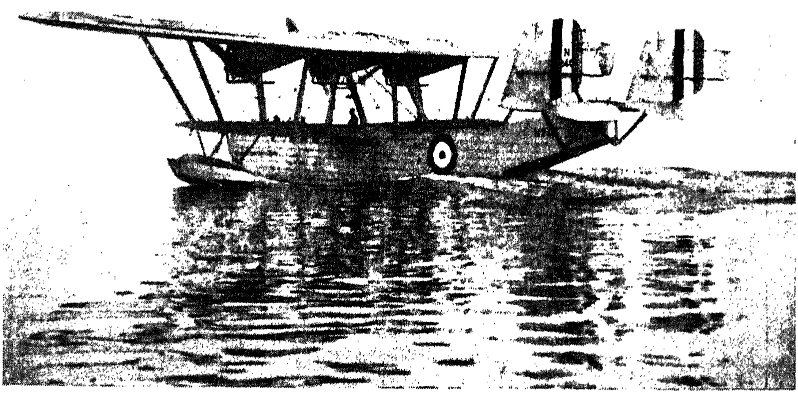


Fig. 4.—THE "SARO" A.7 FLYING BOAT.

Where fairings or packing pieces of wood are allowed to sit up close to the structure, such as around cabin windows, etc., moisture tends to collect. Points such as this should be protected by interposing a good coating of marine glue between the wood and the metal, the wood having been previously varnished or painted.

"Intercrystalline" Corrosion

Another form of corrosion is that known as "intercrystalline" corrosion, and is more difficult to locate than the surface type. It takes the form of fine cracks which are really a sign of a breaking down of the adhesive force holding the grains or crystals of the material together. When this is found, the plate or angle must be replaced. It should be particularly watched for on fittings, etc., made up from duralumin bar. Once started, there is no means of checking it. A third form of corrosion to be guarded against is that due to "galvanic" action, this being set up when two dissimilar metals are in contact, such as duralumin and brass, copper or steel, and this combination is in contact with salt water.

Attachment Fittings

Attachment fittings are usually either of stainless steel or built up of mild steel. The latter material must always be cadmium treated in addition to normalising after welding.

Where these fittings are in contact with the hull or float structure, a good coat of marine glue should be interposed in the jointing faces to prevent the entry of salt water and to keep the two faces out of metallic contact as much as possible. The attachment bolts should also be given a coating of marine glue.

Copper pipes and the various services to the engines should always be held clear of the hull. The writer has known of a case where a flexible drive casing was found to have completely eaten through the well deck of an amphibian aeroplane.

Lightly stressed fittings made of an aluminium-silicon alloy are often employed in hulls and will corrode rapidly under the action of salt water. These should be carefully watched, as once started it is very rapid.

It will be found that the inspection and maintenance of the structures, from the point of structural failure or collapse, presents less difficulty as compared to land-planes of wood or metal construction.

The region to be most carefully watched is the forward planing bottom, in the region of the main step, spar bulkheads and adjacent frames.

"Flatting"

As this section of the hull is subjected to a certain amount of buffeting whilst the seaplane is landing, taking off and taxying, there is a tendency for the plating to "flat," or become dished between frames and inter-

costals. Providing the "flatting" is slight, it is not detrimental to the hull as a unit, but frames and gussets should be carefully checked for signs of buckling where these are riveted to the bottom plating.

If flying control torque shafts, levers or brackets are carried close to the bottom plating, there is always a danger of these being fouled by a buckled frame or stiffening gusset. A small stiffening angle, riveted to the interior of the planing bottom, will often guard against this happening when a seaplane or flying boat is operating under adverse conditions.

In the case of floats, the flats may be found to form at the forward or nose end, and at the float step.

Damage Caused by Floating Articles

Damage is often caused when landing and taking off by hitting small floating articles or driftwood. A dinghy or motor boat may also cause damage to the plating and frames at the water line, and the former should always have their gunwales protected by padding, or other means. If it is found that a sharp local indentation has been made in the plating about the water line, it should be left undisturbed, providing it is not of an extensive nature.

Attempting to dress this out will often lead to fracturing of the plate along the line of the indentation. If extensive, it should be dressed out and a neatly shaped patch riveted over that area, using single line riveting and applying marine glue between the patch plate and plating, to ensure that water cannot penetrate and cause corrosion. This perhaps would not be observed, if behind the patch, until the plate was eaten through. Buckling of the forward bottom and side plating may be caused by a heavy landing or taxying in a rough sea. The easiest way to observe this is to "sight" along the plating, chines and gunwales, first from the bow, and then the stern. Any point where a departure from a "fair" line is observed should be closely examined.

Movement of a Plate or Frame

Movement of a plate or frame will be indicated by the protective coat wrinkling or cracking. Buckling of the side plating may also occur after an exceptionally heavy landing, when the "ripple" in the plates will tend to run from the chines near the main step to either the front or rear spar frames. This type of buckling is serious and should be investigated, however slight. No attempt should be made to rectify this by merely dressing out the plates. If the adjacent main frames are buckled, they will often return to their original form by removing the damaged plate.

The manufacturers issue approved repair schemes to cover the different types of repairs, and these should be referred to. They may involve the fitting of additional "Zed" or channel section stiffeners in the weakened area.

Once a plate or frame is distorted, its strength is greatly reduced. Slight buckles or twists in frames may often be rectified by dressing out and the fitting of stiffening pieces of the same section inside the original.

If a Heavy Bow Landing is made

If a heavy bow landing is made, the keelson web and angles may show signs of buckling in addition to the forward side plating. The keelson should be closely examined from the bow to the main step, including the gusset plates and frame attachments to the keelson.

Rivet heads may also have sheared. Buckling will be readily traced at inaccessible points by running the hand lightly over the keelson web, when any irregularity will be noticed.

When making an internal inspection of a hull or float, a system should be worked to, starting either at the bow or stern, and checking each frame and section of keelson in turn.

All main frames are numbered from bow to stern, and the easiest method of locating any particular frame is to remember the chief frames, such as the front and rear spar bulkheads. The latter are usually of much stouter construction than the remainder, and carry the main plane or strut attachment fittings. The corners of frames are usually stiffened up by reinforcing plates, and any buckling at these points should receive immediate attention.

Buckling of Fin Plating and Frames

The fin plating and frames at the stern should be watched for buckling caused by heavy tail unit loads. This may occur at the inner curvature of the plating. Distortion at this point may cause the tail adjusting slider tube to become stiff in operation or seize in its bearings. All attachment fittings at the stern should be checked for movement and corrosion, owing to the fact that dissimilar metals are involved.

If there is any doubt as to the condition of the plating below these fittings, it is always advisable to remove them for a further examination.

The main plane or float attachment fittings are usually built up or machined from one of the steels in the stainless group, as also are the stressed tubular members. These should be closely examined for cracks, particularly in the jaws of machined fork ends.

No attempt should be made to carry out repairs to this type of fitting by welding.

Other steels employed in the building up of hull fittings are all in the stainless, high chromium content group. No heat treatment is required after welding these steels as is the case with the majority of other steels.

Cracks along Edge of Welding

Cracks sometimes develop along the edge of the welding and a watch should be kept for these. The welding rod used when building up these

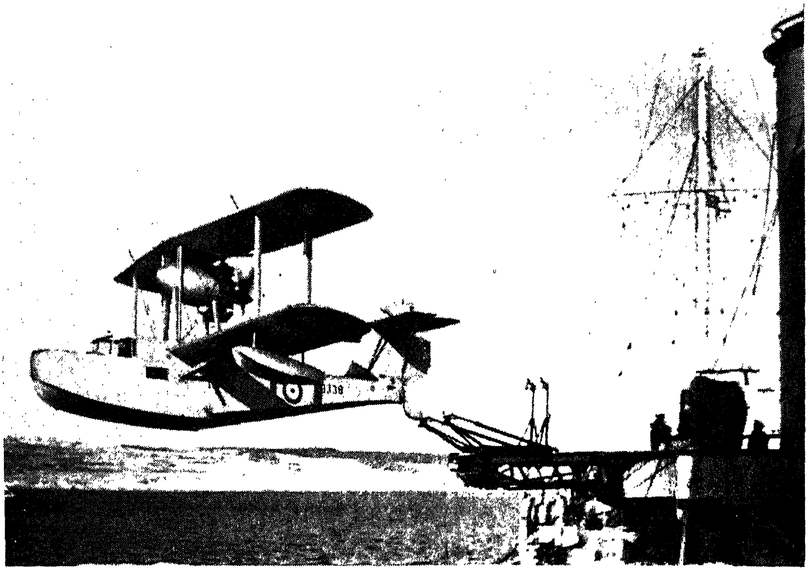


Fig. 5.—VICKERS SUPERMARINE "WALRUS" AMPHIBIAN FLYING BOAT.
Constructed almost entirely of metal, stainless steel and duralumin.

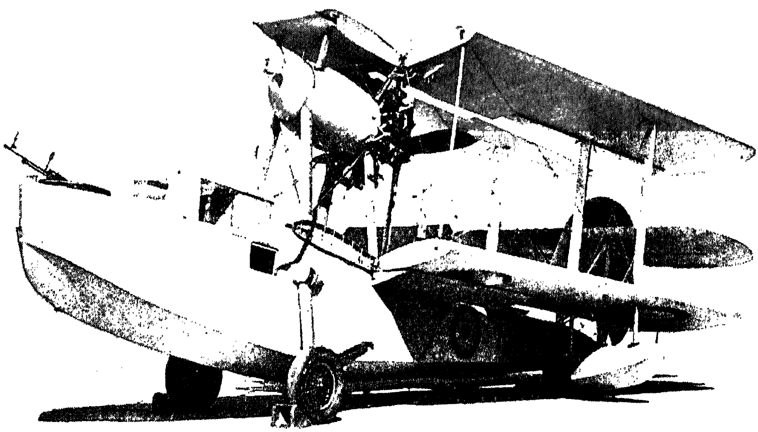


Fig. 6.—ANOTHER VIEW OF THE VICKERS SUPERMARINE AMPHIBIAN FLYING BOAT, SHOWING THE WINGS FOLDED FOR STOWAGE.

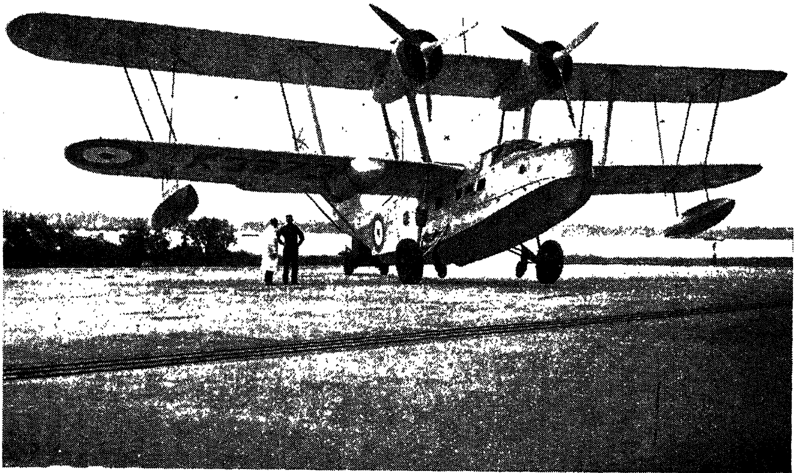


Fig. 7.—VICKERS SUPERMARINE "STRANRAER" TWIN-ENGINED FLYING BOAT.
The hull construction is of alclad with main attachment fittings of stainless steel.

Fig. 8.—A FLOAT BIPLANE AMPHIBIAN.

fittings is that which complies with the correct specification, that is, stainless steel rod. On no account should mild steel welding rod be used.

These steels resist corrosion, although a brown stain may be observed on fittings which are left unprotected. This can usually be rubbed off as it does not penetrate.

Another special steel employed for highly stressed fittings is DTD.60A. This has a proof stress of 45 tons, and is always hardened and tempered after being worked. It is delivered in the soft condition and it is not advisable to weld this material for repair purposes—it being safer to replace the fitting.

Mooring bollards and their anchorages should be periodically checked for security, as the safety of the seaplane or flying boat in the moored condition will depend upon them.

When dealing with amphibian hulls, there are additional points to inspect for signs of failure, chief of which are the hull plating in the region of the top axle and radius rod fittings. Damage may also be caused around the tail skid attachment fittings in making a heavy tail landing. The hull frames at the point of attachment of the axle fittings are usually of channel section and of heavier gauge than the others.

Swashboards

Whilst inspecting the interior of the hull, the swashboards should be checked for being easily fitted to the bulkheads. These swashboards are for use in dividing the hull into watertight compartments, and it is essential that they be kept in a serviceable condition, in the event of the hull bottom being holed whilst the flying boat is afloat.

The compartment housing the drogues should have its drains kept free and should be regularly flushed out.

The warp line should be securely attached to both the drogue and the drogue attachment fitting on the hull. The trip line should also be kept attached to the drogue.

The bilge pump should be kept in a serviceable condition and all stowages in the hull for the marine equipment, such as anchor and chain, etc., should be kept serviceable.

The attachment shackle for the anchor chain is usually in the bow compartment at the keelson, and this should be checked, as also should the attachment of the chain to its shackle.

Testing Hull or Float for Water-tightness

Testing of the hull or float for water-tightness is usually carried out by means of a high pressure jet of water from a hose. The test should be methodically carried out, working through the length of the structure from bow to stern, and directing the jet around all rivets, plate laps, chine angles, etc., including all windows and their framings. An observer inside the hull notes any leaking points. This test is not infallible, but

if only slight leaks are found after launching they can often be remedied by caulking with a cotton thread soaked in marine glue.

Floats may be tested by one of two other methods. One is to load the float to its water line, after being placed in a large tank, and noting leaks by looking through the hand holes in the float decking.

The other method is to fill the interior with fresh water up to the water line, or slightly above, and watch for leaks on the outside.

Temporary Repair

If a hull or float is holed below the water line, it is often necessary to make a temporary repair to enable the seaplane to be flown to some place where a proper repair can be made. The exact method of making the repair will be at the discretion of the ground engineer, but if it is in the region of the forward planing bottom, one should be liberal with regard to the size of the patch, the pitching of the bolts or rivets and the gauge of the material.

The material, of course, should be the same as that employed in the structure. Where this is not possible, the two surfaces should be well insulated by marine glue or varnish.

Bolts should be used in lieu of rivets, in fact, the former are better than badly or hurriedly fitted rivets.

Permanent Repair

On the boat reaching its base, a proper repair would be carried out by cutting out the jagged portion and cleaning it up to a regular shape. A patch plate would then be fitted of the same gauge material as the hull plating, also fitting an angle stiffener behind the patch, inside the hull. The whole would then be riveted together, using a double staggered line of rivets. All surfaces in contact would be liberally smeared with marine glue.

When carrying out the riveting, the manufactured head should be on the outside of the plating, where possible. Prior to riveting, a number of bolts should be spaced around the patch and riveting carried out between these. The bolts should then be removed and the riveting completed.

The same method applies to a plate lap, and its purpose is to prevent the plate " creeping " during riveting and the rivet holes failing to register.

Where a plate overlaps another, the edges should always be dressed down after riveting to prevent water from lying in the crevices. The riveting tends to cause the edge of the plates to curl slightly.

To remove old rivets it is advisable to drill into the head a certain depth with an undersize drill, and then remove the head with a chisel, afterwards drifting out the shank. If rivet holes are elongated, it is best to open them up to the next size of rivet and fit oversize rivets.

Often it is difficult to harden up awkwardly placed rivets in carrying

out a repair. In cases such as this, use could be made of watertight bolts. These have a slightly tapered shank below the head, to ensure a good watertight fit. If a number of plates have to be replaced, the whole structure should be well supported before removing the old plates, to prevent a collapse of the hull in that region.

Datum blocks are provided on a hull, but no trueing up is possible in service. The fore and aft datum blocks are usually attached to the outside of the hull plating, and are parallel to the hull datum. The lateral levelling blocks are often mounted on the front or rear spar frames. The actual hull datum is sometimes indicated by drilling a small hole in each main frame, a line passing through these holes being the hull datum. The datum blocks are for reference when aligning the superstructure, tail unit, etc.

In the case of floats, reference is made, when aligning, to the fuselage datum blocks.

Concluding these notes, it cannot be too highly stressed that corrosion is the most important factor with which the inspector or ground engineer has to deal, and the constant and liberal use of fresh water, under pressure, is the best means of combating it and obtaining long and useful service from the structure.

THE GIPSY SIX SERIES I AND II AERO ENGINES

RUNNING AND MAINTENANCE

By A. J. Brant

Service Manager, de Havilland Aircraft Co. Ltd.

GIPSY SIX SERIES I

ALL running instructions for the Gipsy Six Series I engine are the same as outlined for the Gipsy Major engine (see pp. 11–15).

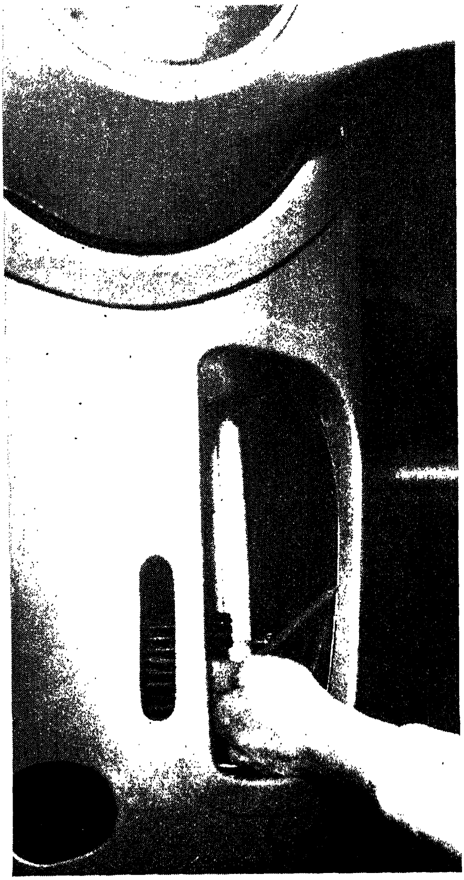
Possible Troubles

Troubles outlined for the Gipsy Major (see pp. 17 and 18) apply to this engine, but in addition the following may be a cause of misfiring :—

Cases have occurred where tracking has taken place between the high tension segments in the distributor, resulting in the burning of the moulded material. This is due to an accumulation of moisture in the distributor. It has the appearance of a crack or cracks in the moulding adjacent to the electrodes. The burning of the moulding can be eliminated by varnishing the inside of the distributor, using B.T.H. varnish No. 93. This varnish should be applied evenly over the whole of the inside surface and care should be taken that no bubbles are formed.

After varnishing, the moulding should be left in air for eight hours to permit the varnish to dry. The varnish mentioned may be obtained from the magneto or engine manufacturers. All up-to-date high tension pick-up leads between magnetos and distributor have spring end contacts. Any of the old solid end type should be changed when convenient. Occasional cases of trouble have occurred, caused by the loosening of the terminal with the solid ends, but the following instructions for fitting if carried out will eliminate this possibility.

1. Temporarily assemble distributor cover on distributor.
2. With high tension lead disconnected from magneto, screw up terminal, finger-tight.
3. Slacken the two screws retaining distributor cover to give 0·010 in. gap between cover and distributor, again tighten terminal finger-tight and take up 0·010 in. gap by tightening the two screws.
4. Before connecting up the lead to the magneto, give the wire a half turn in a clockwise direction so that the wire tends to tighten the terminal in the cover.



1.—HOLE IN NOSE COWL SHOULD LINE UP WITH ENGINE AIRSCOOP.

Complete Overhaul

The same general principles apply as for the Gipsy Major engine (see p. 20 and following pages).

Clearances

The clearances are similar to those laid down for the Gipsy Major engine, but reference must be made to the engine handbook before passing parts as serviceable.

GIPSY SIX SERIES II RECOMMENDED MAINTENANCE SCHEDULE

Inspection of Gipsy Six Series II

The Gipsy Six Series II aero engine will normally be inspected and maintained by licensed ground engineers, and their training will indicate the nature of the inspection routine and work to ensure reliable and care-free operation, but for the guidance of all concerned the following covers broadly the points to be observed.

Daily in Preparation for Flight

(i) Attention to pilot's previous reports, if any.
(ii) Check all controls for free movement and normal operation.
(iii) Inspect engines and installations to ensure no slacking, displacement, chafing or leaks.
(iv) Rotate spindles in " Auto-Klean " filters.
(v) Check fuel pumps independently by operating priming levers.
(vi) Run engines.
(vii) Verify engine cowling properly fastened.

After every Twenty-five Hours' Flying

(i) Routine as daily schedule including the following :—

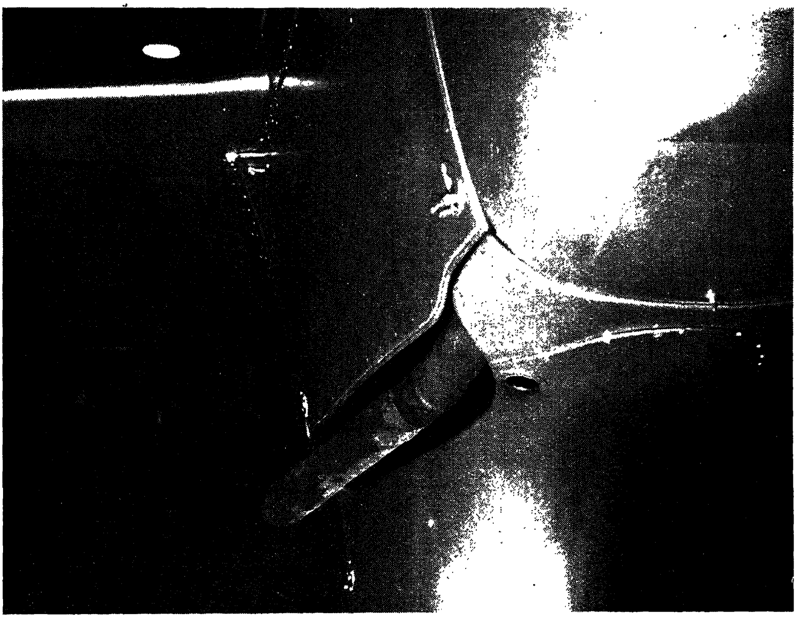


Fig. 2.—A PROPORTION OF THE ENGINE BAY AIR OUTLET AREA MUST BE AROUND THE EXHAUST MANIFOLD.

(ii) Remove sparking plugs, dismantle, clean, re-assemble and pressure test.
(iii) Check valve clearances and reset if necessary.
(iv) Clean suction oil filters.
(v) Clean fuel filters.
(vi) Remove and check carburetter jets and flush through float chamber, including pipe lines between pumps and carburetter.
(vii) Check contact-breaker gaps and reset if necessary and clean distributors.
(viii) Drain oil system, including valve gear covers; replenish with new oil.
(ix) Check tightness of airscrew bolts. This should be done more frequently if airscrew of wooden construction is new and if the aeroplane is operating in a hot climate.
(x) Lubricate all working parts of controls.

After 250 Hours' Flying

The "Auto-Klean" pressure oil filter should be dismantled from its casing and cleaned, including the casing.

After 600 Hours' Flying

The engine should be taken from the airframe and given a complete overhaul.

COMPLETE OVERHAUL

Removal of Fixed Pitch Airscrew and Hub

Remove the split pin and slotted nut at the front of the spinner, which will allow the spinner to be pulled off. Undo the four cheese-head screws and remove the locking plates. Using box spanner and tommy bar, unscrew the crankshaft front nut. As this nut is unscrewed the aluminium bronze cone at the front of the boss will be pulled forward up against the withdrawal nut, so pulling the hub, together with the airscrew, from the splines of the crankshaft.

Removal of Controllable Pitch Airscrew

(*a*) Disengage the airscrew cylinder head lock ring and remove the cylinder head, using the box spanner and special tommy bar provided in the running tool kit.

(*b*) Disengage the piston lock ring by removing split pins.

(*c*) Unscrew the piston, using the same box spanner and tommy bar as for the cylinder head. The box spanner fits both external and internal hexagons. This operation will pull the complete hub off the engine shaft.

Removal of Engine from Airframe

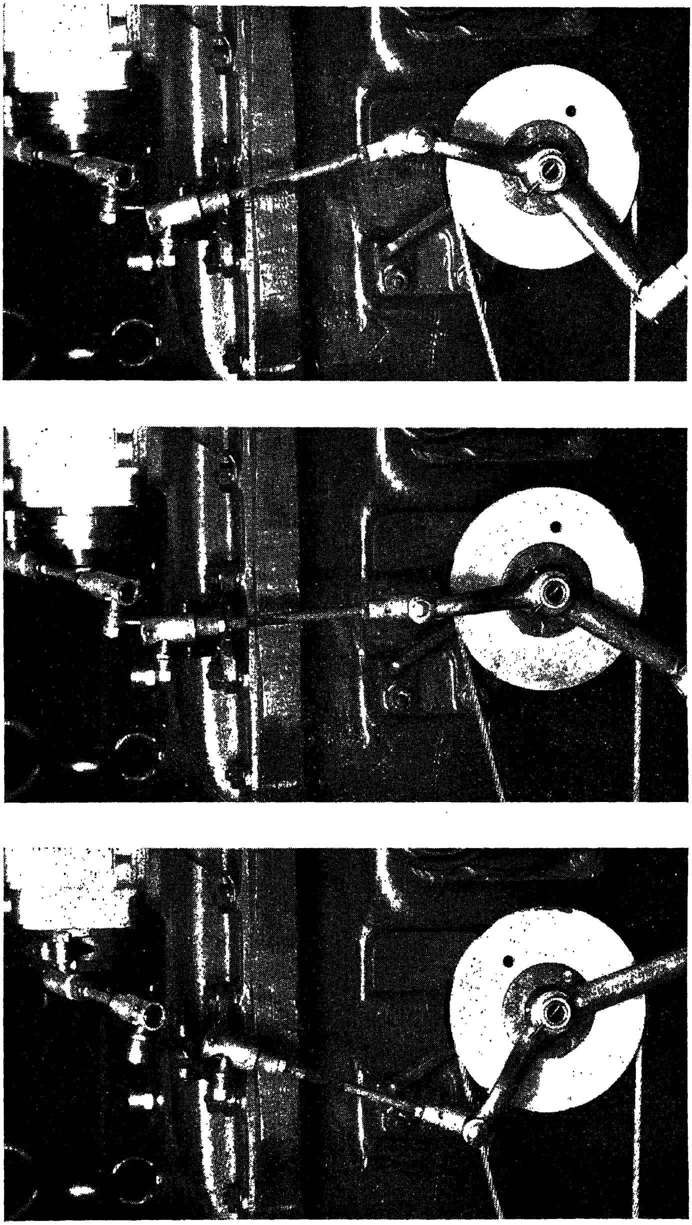
Remove cowling, carburetter air intake, disconnect fuel pipes, oil pipes, engine controls, remove exhaust manifold, using special spanner, disconnect tachometer drive, breather pipe, and remove caps which hold engine foot mounting blocks. If electric starter is fitted, remove leads from starter, and if necessary to clear airframe structure when engine is being lifted out, remove starter itself by undoing the six retaining nuts. The engine should now be slung by the two eyebolts in the top cover and with the engine still on the sling, if available, fit engine feet which are more suitable for bolting to the workshop engine stand, which preferably should be of the invertible type. Remove locking wires, nuts and valve gear covers and then invert engine.

Removal of Induction Manifold, Ignition Equipment and Cowling

Remove induction pipes and carburetters complete as one unit, using universal spanner to remove nuts holding induction pipes to cylinder heads. Remove distributors with high tension leads and carrier wire by undoing the four retaining bolts. Remove cylinder baffles, then sparking plugs, using box spanner and tommy bar.

Removal of Rocker Spindles, Rockers and Tappet Rods

(i) Remove the clamping bolts holding the valve rocker spindles in



Figs. 3, 4 and 5.—SHOWING PROGRESSIVE POSITIONS OF THE BELL CRANK LEVER WHICH AUTOMATICALLY CAUSES A SLIGHT RETARD OF THE MAGNETOS IN THE FULL THROTTLE POSITION.

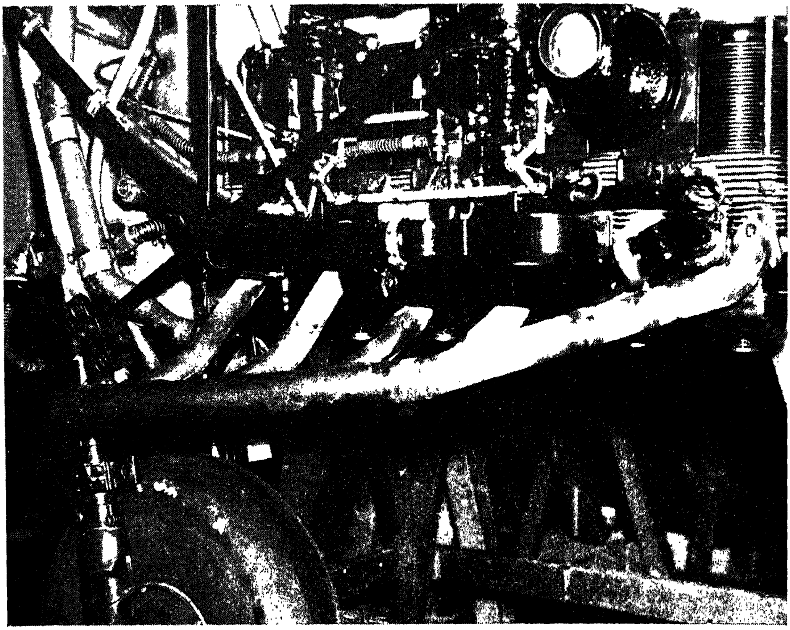


Fig. 6.—A TYPICAL EXHAUST MANIFOLD SYSTEM FOR THE GIPSY SIX SERIES I ENGINE.

place in the rocker brackets and, using special extractor, withdraw rocker spindles.

(ii) The rockers and tappet rods may now be removed.

(iii) Telescope the two halves of the tappet rod casing tube together, and remove from position.

Removal of Cylinder Heads and Barrels

Loosen all cylinder head nuts, using special spanner. Ease cylinder heads up as these are being unscrewed and remove cylinder baffle brackets and nuts. Lift cylinder head clear of studs. Next remove cylinders. These should be eased carefully with pistons on outer dead centre, supporting the pistons as the cylinders are lifted clear ; should the cylinders be stuck in the crankcase, striking them sideways alternately with the flat of the hand should loosen them.

Removal of Oil Pump Unit

Remove flexible airscrew feed pipe from crankcase and oil pump casing, which is fitted when engine is built for use with a de Havilland variable pitch airscrew. Remove the three cast elektron oil pipes from the rear of the oil pump unit. Unscrew union nut on steel pipe leading to suction filter and also the nuts securing the suction filter bracket to

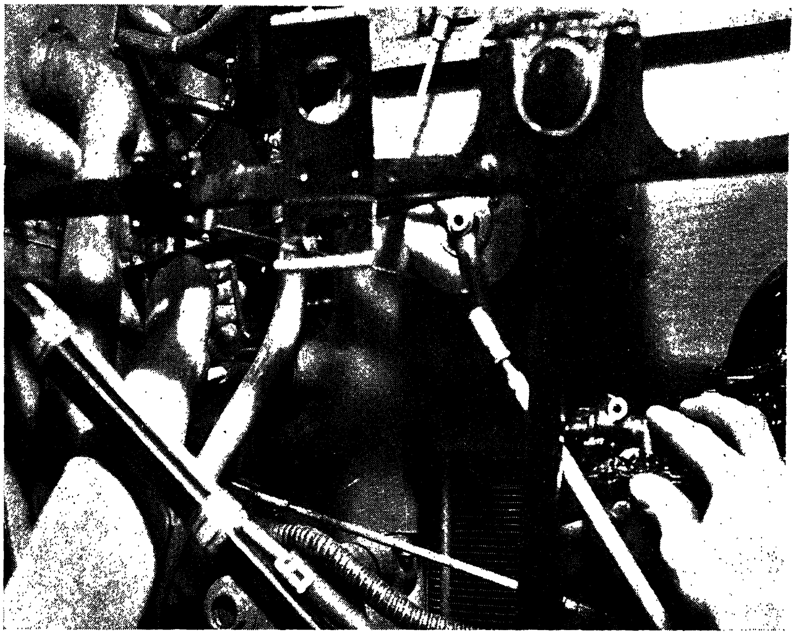


Fig. 7.—METHOD OF FLOODING CARBURETTER.
To flood carburetter depress tickler and operate priming lever on one fuel pump.

the oil pump unit. The oil pump units can now be removed by undoing the nuts on the attachment studs and sliding the unit up the studs.

Removal of Pistons

Remove circlips from one end of each gudgeon pin, using the circlip extractor and a screwdriver. Care should be taken to avoid damaging or burring the groove or slot at end of the gudgeon pin during this operation. If a burr is accidentally raised, stone it off to prevent scoring of the bore in the piston boss and connecting rod small end during removal of the gudgeon pin. After removal of the washers, the gudgeon pin can be pushed out and the piston removed. If the gudgeon pin is too tight to be removed by hand, it should be extracted by using the gudgeon pin extractor.

Removal of Top Cover, Front Cover, and Thrust Race

Invert engine. Remove top cover by undoing all retaining bolts and lifting clear. Remove fuel pump and tachometer gearbox and slide fuel pump drive coupling from rear of camshaft. To remove the phosphor bronze front cover, first bend back the locking tabs and then unscrew the six retaining nuts. The front cover can now be removed carefully

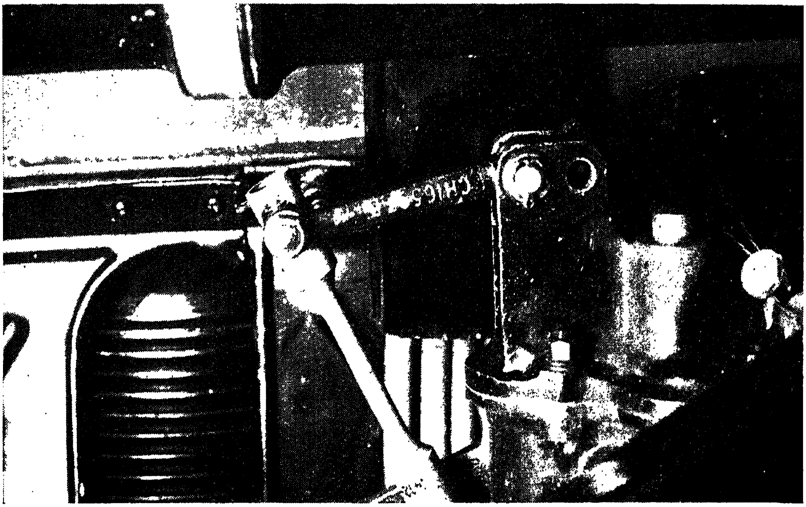


Fig. 8.—THE MIXTURE CONTROL ON A.I.48, TYPE E, AND SUBSEQUENT ISSUE CARBURETTERS.

together with the oil flinger. The thrust race housing together with the thrust race is now withdrawn, using extractor bolts. A gentle tap using a soft drift will be sufficient to remove the crankshaft steel rear cone.

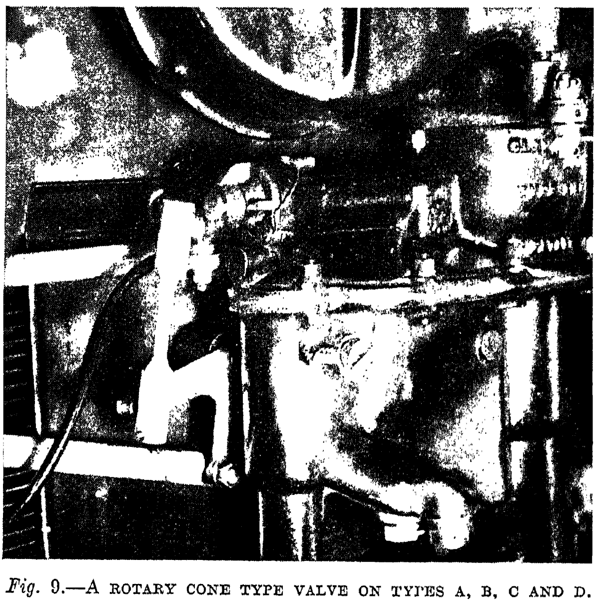


Fig. 9.—A ROTARY CONE TYPE VALVE ON TYPES A, B, C AND D.

Removal of Connecting Rods

Take out split pins and unscrew nuts on big end bolts, using spanner. Tap bolts down, lift caps and bearing shell clear of crankpin, lower connecting rod and reassemble cap with bearings, nuts and washers on rod. Remove main bearings with cap; to do this, remove split pins and bend down

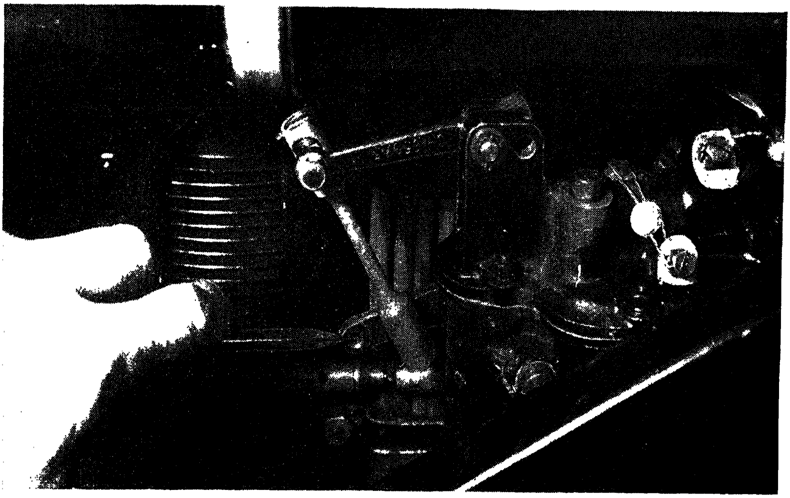


Fig. 10.—THE CARBURETTER MIXTURE CONTROL LEVER INDICATING TWO HOLES FOR THE ALTERNATIVE OPERATION RANGE OF UP TO 15,000 FT. AND OVER 15,000 FT.

Connect control rod to inner hole when aeroplane is normally operated under 15,000 ft. and to outer hole when used often for over 15,000 ft.

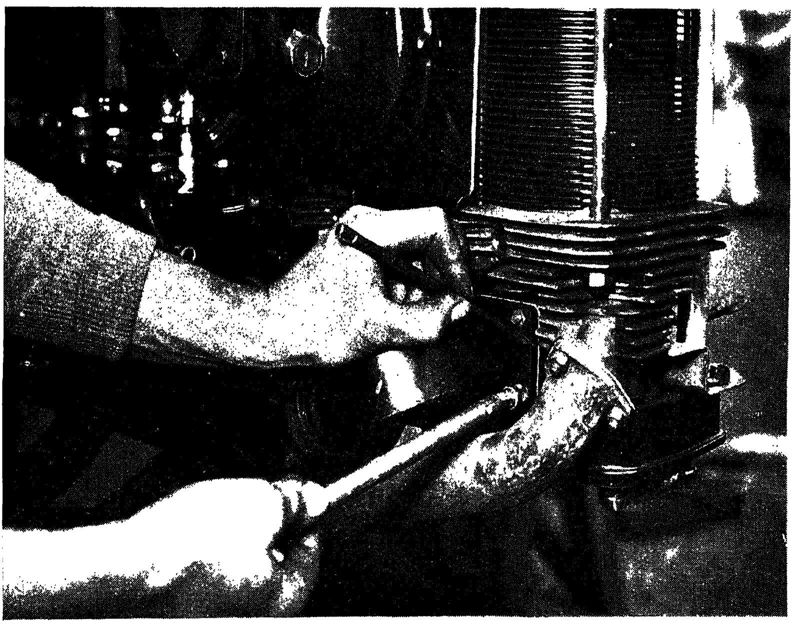


Fig. 11.—CHECKING INDUCTION MANIFOLD NUTS, WITH PARTICULAR ATTENTION TO THE CONDITION OF JOINT WASHER.

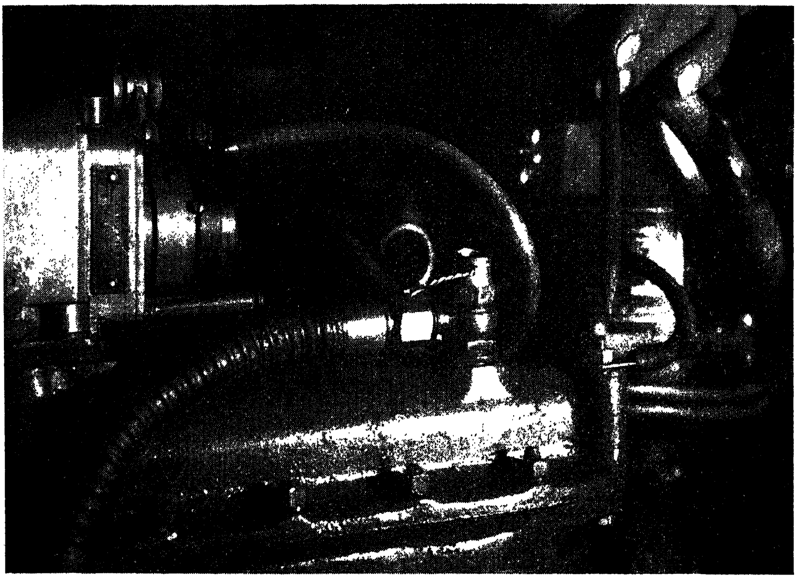


Fig. 12.—MAGNETO SWITCH EARTH LEAD CONNECTION ON ENGINE.

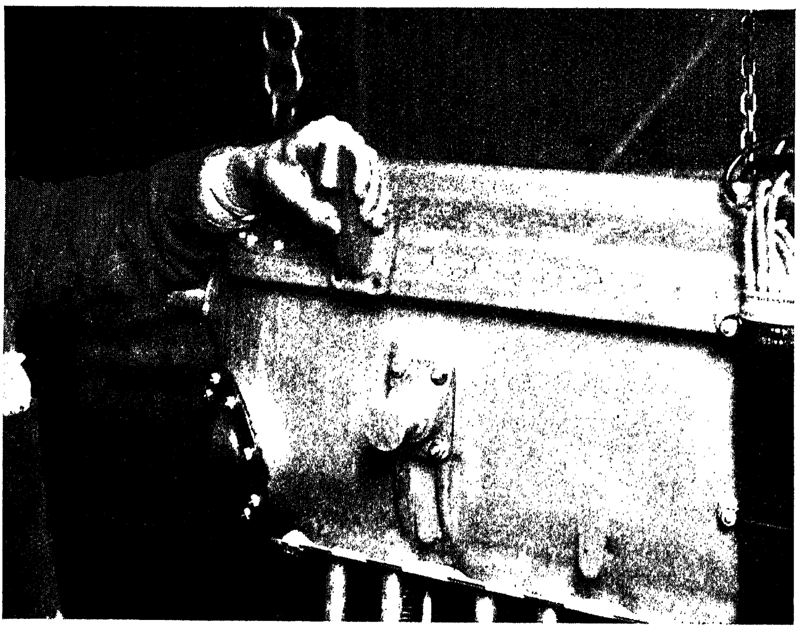


Fig. 13.—TO FACILITATE TRESTLING AND BENCH TESTING IN CONNECTION WITH OVERHAUL THE STANDARD ENGINE FEET ARE REMOVED AND SPECIAL TEST BED FEET FITTED.

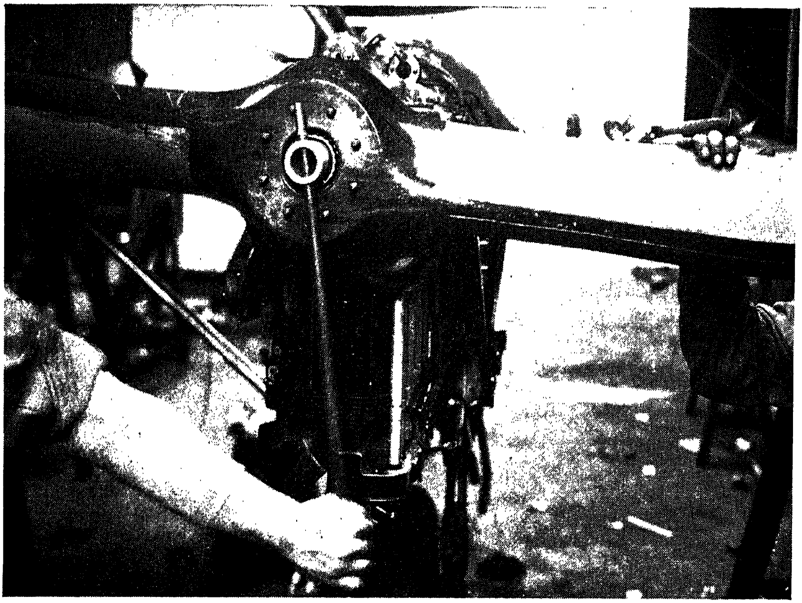


Fig. 14.—REMOVING AIRSCREW BOSS FROM SHAFT.

locking tabs and unscrew nuts, using spanner. Lift off caps complete with bearing.

Removal of Crankshaft

Revolve crankshaft until No. 1 throw is vertically upwards, lift rear end of crankshaft until crankshaft gear will clear the main bearing studs of No. 2 bearing; the shaft may then be withdrawn; the lower halves of the main bearing may be lifted out of the half bores without difficulty.

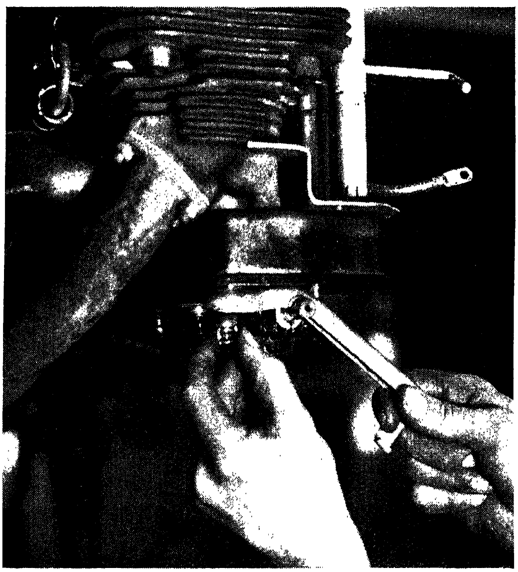


Fig. 15.—THE VALVE COMPRESSING TOOL BEING USED TO DEPRESS VALVE SPRINGS AND REMOVE COLLETS.

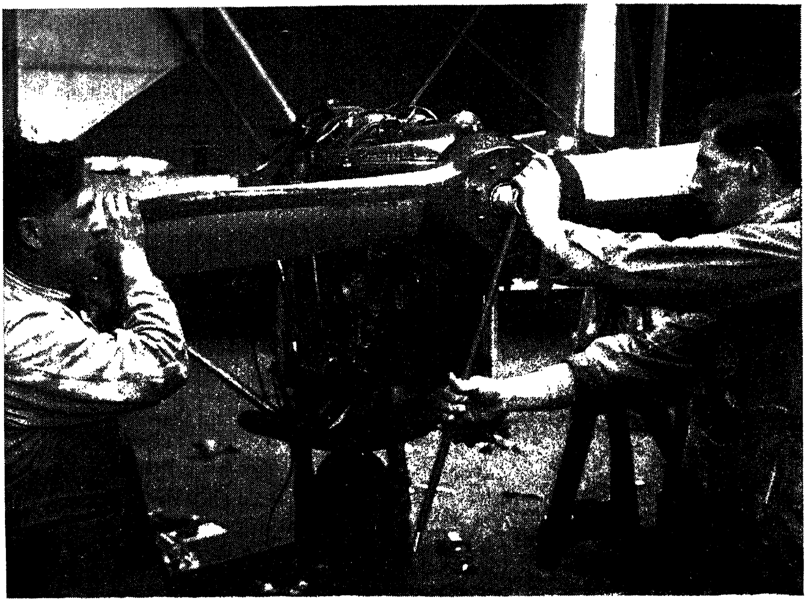


Fig. 16.—REMOVING CRANKSHAFT NUT, USING AIRSCREW TO PREVENT SHAFT MOVING.

Removal of Oil Pump Drive Shaft and Housing

To remove oil pump drive bevel gear shaft and housing from crankcase, withdraw split pins and unscrew nuts at lower end of housing.

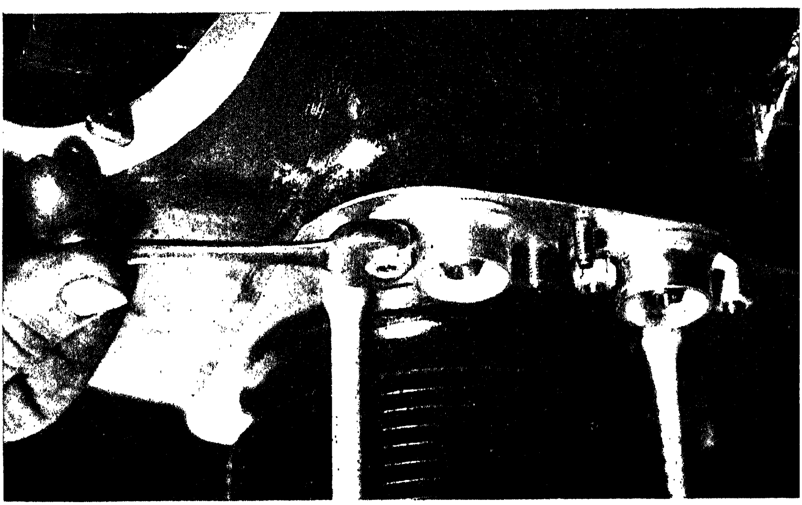


Fig. 17.—REMOVING TAPPET GUIDES FROM CRANKCASE.

The housing complete with shaft can then be tapped out of crankcase.

Removal of Bevel Gear—Rear End of Camshaft

Bend tab out of slot in retaining nut and unscrew nut, using box spanner. Screw body of puller on to thread of gear and pull off shaft by revolving screw which, passing through the body of puller, abuts end of slots in camshaft.

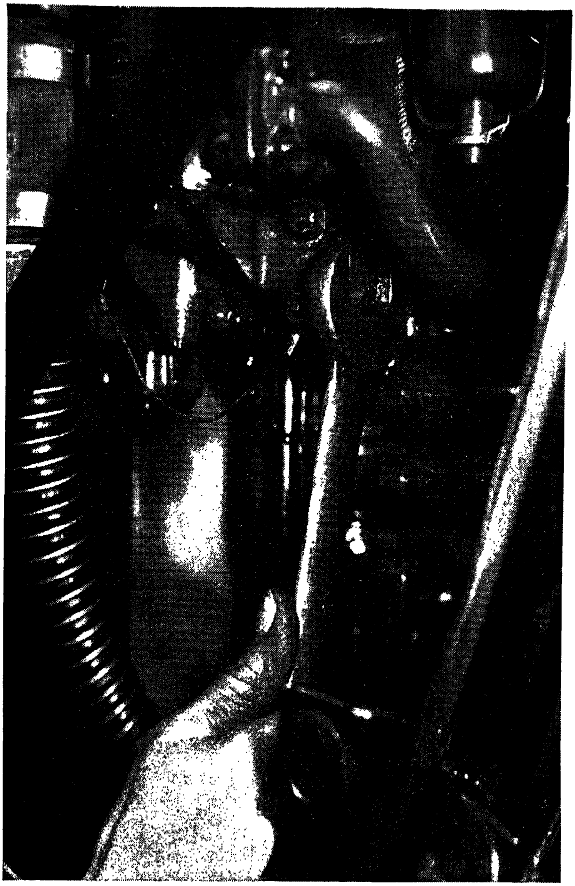


Fig. 18.—THE RELIEF VALVE CAP BEING UNSCREWED.

Removal of Spur Gear—Front End of Camshaft

Bend tab out of slot in retaining nut of camshaft and spur gear and unscrew nut, using box spanner. Attach bar of puller to gear by means of the bolts, which, passing through the bar, are screwed into the two tapped holes in the gear. Pull gear off shaft by revolving screw which, passing through body of puller, abuts end of shaft.

Fig. 19.—THE RELIEF VALVE BEING CLEANED AND EXAMINED.

Removal of Idler Spindle and Camshaft

Bend tab out of slot in retaining nut of idler spindle and unscrew nut, using box spanner. Tap idler spindle rearwards, using soft drift on front

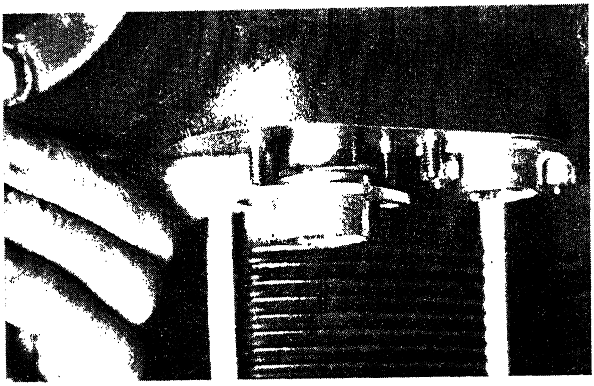


Fig. 20.—DERMATINE JOINTING RINGS ARE FITTED BETWEEN TAPPET GUIDE FLANGE AND CRANKCASE.

end of shaft and lower idler gear cluster to bottom of crankcase. To remove camshaft rear bearing, bend tabs on washers clear of retaining nuts, unscrew nuts and withdraw bearing. Remove camshaft, withdraw carefully through tunnel towards front of crankcase. Lift out idler cluster. Remove tappets and guides together by tapping tappets with a soft drift, after removing retaining nuts.

Removal of Oil Suction Pipe

Bend back tab on lockwasher and remove plug at rear of crankcase, using ring spanner. Remove spring and withdraw suction oil pipe, using extractor towards rear of crankcase. Remove crankcase breather situated at rear of crankcase by bending back locking tab, unscrewing nut and then withdrawing breather baffle and elbow.

DISMANTLING OF COMPONENTS

Dismantling of Airscrew Hub

Remove the eight airscrew bolts, nuts and spring steel washers with box spanner and tommy bar. The airscrew front plate and the airscrew itself can now be withdrawn. Using ring spanner, unscrew the withdrawal nut at the front of the boss which will allow the split cone and crankshaft front nut to be removed.

Dismantling of Crankshaft

No attempt should be made to remove the crankshaft gear, as this is pressed on by the manufacturers, and any attempt at removal might damage the crankshaft. Remove split pin, nut and retaining collar of starter dog, and using extractor, withdraw the starter dog. Withdraw split pins, nuts and bolts retaining oil seals, then remove seals.

Dismantling of Oil Pump and Filter Assembly

Remove scavenge suction filters, using box spanner for the caps. Remove pressure filter, using box spanner for the cap. Remove taper

pin retaining driving gear; this can be tapped out, using a small drift; after first filing off, flush the small end. Remove the remaining three nuts retaining casing containing reducing valve and release valve. Remove three nuts retaining reducing valve cover, lift off cover and valve may be withdrawn.

If compressed air is available the simplest method is to blow the valve out from the underside. Bend back locking tabs and using box spanner, undo release valve plugs and withdraw washers, springs and plungers. Remove seven nuts and washers retaining oil pumps, slide cover, then casing of the first scavenge pump off the studs.

Fig. 21.—A SOFT ALUMINIUM JOINTING WASHER IS FITTED BETWEEN VALVE GUIDES AND VALVE GEAR CASING (SERIES I).

The pump gears may then be easily removed by sliding up their spindles; remove the keys, remove the dividing plate and repeat the above with the second scavenge pump. The pump driving gear may now be removed by removing nut and gently tapping shaft through gear with a soft drift. The driven and driving spindles with the integral pressure pump gears may then be withdrawn. Bend back the locking tabs and undo the four nuts holding the airscrew feed cock assembly into position, and withdraw the assembly complete.

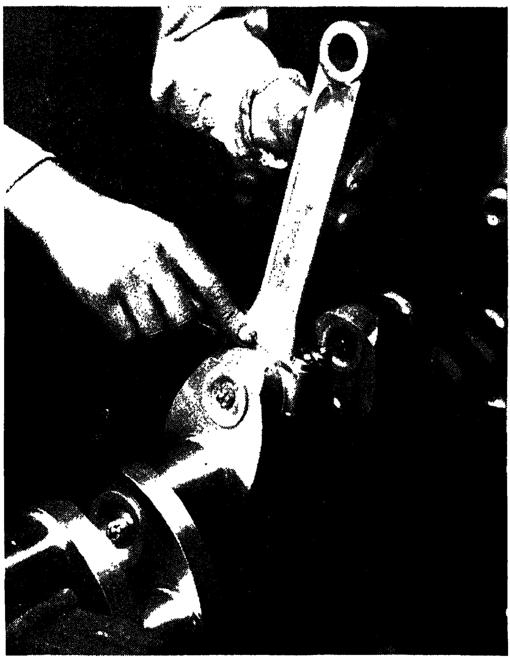


Fig. 22.—CHECKING CONNECTING ROD BEARING SIDE CLEARANCES.

Dismantling of Top Cover

If a vacuum air pump

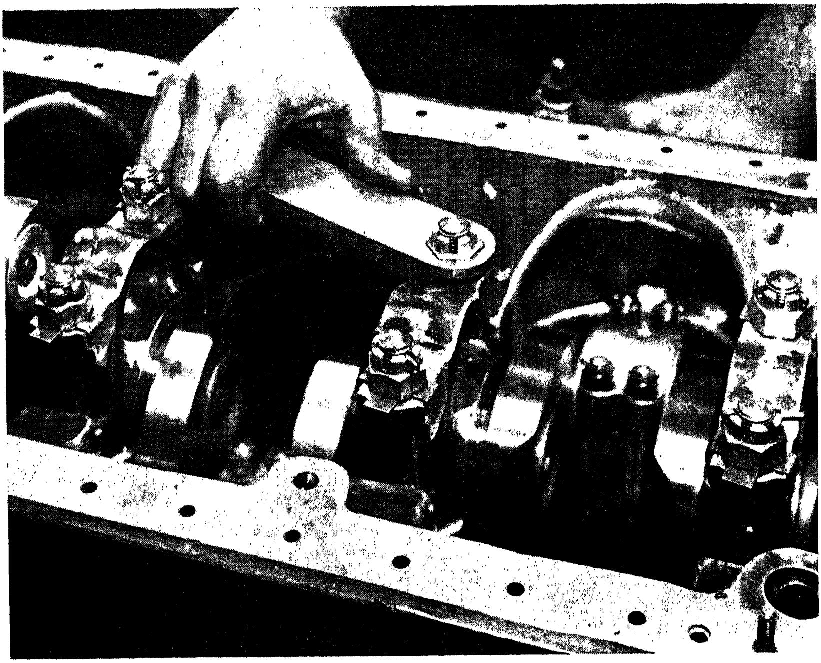


Fig. 23.—SHOWING SPECIAL SPANNER WHICH ALLOWS CORRECT LEVERAGE FOR TIGHTENING MAIN BEARING NUTS.

is fitted, remove by bending back locking tabs and undoing the four retaining nuts. The gearbox can now be lifted off the retaining studs after first removing the bolts securing it to the starboard side of the top cover. If neither gearbox nor pump has been fitted, the square cast elektron cover plate will have to be removed from its four studs. Remove the magnetos by undoing the four retaining screws.

Telescope the driving shaft cover tube which lies between the two magnetos together until the rear of the tube can be placed in front of the cast lug on the top cover provided for the purpose. It will now be possible to bend back the locking tab and unscrew the driving spindle nut with spanner.

The short driving spindle together with the long driving shaft can now be withdrawn towards the rear of the case. The cover tube can now be taken out of position and withdrawn towards the outside of the top cover. Withdraw distributor backplates towards outside of top cover by unlocking and undoing the six nuts holding them in position. Invert top cover and bend back the locking tabs. Undo the eight nuts holding bearing caps in position and lift out distributor driving gears. Undo the eight nuts holding bearing caps in position and lift out top cover main driving shaft.

Dismantling of Idler Gear—Front Main Bearing Cap

Remove split pin, unscrew nut, withdraw bolt and idler gear. Remove idler spindle from bearing cap by tapping out with a soft drift.

Dismantling Tachometer Drive Attachment

Remove nuts and spring washers which hold bronze cover to casing, then remove cover on driven gear; to withdraw driving gear and spindle, remove split pin and nut retaining gear, then tap spindle through gear with a soft drift.

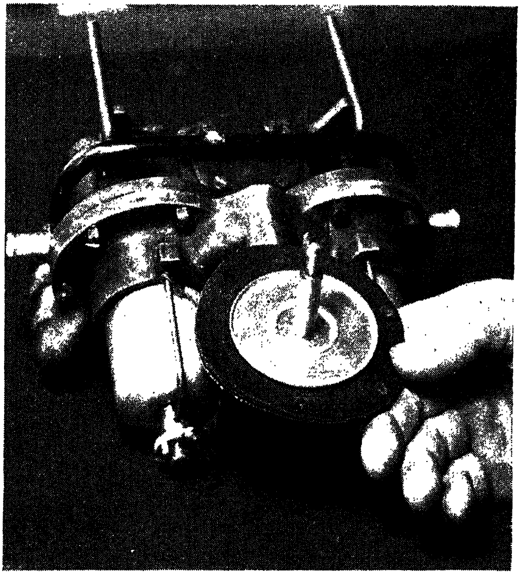


Fig. 24.—AMAL FUEL PUMP DIAPHRAGM AND SPINDLE ASSEMBLY.

Dismantling of Cylinder Heads

The rockers and the spindles have already been removed as described above. Place the cylinder head over a small block of wood sufficiently thick to allow the valves to be held in place. Depress the valve collar, using a valve spring compressor. The collets can then be removed from the valve stems. Remove the compressor and withdraw the springs and collets. After lifting the cylinder head off the wooden block the valves may be withdrawn.

Dismantling of Pistons

Stand the piston on the bench with the skirt downwards, and remove rings. Commence with the top ring and slide all rings upwards, that is, towards the crown of the piston.

INSPECTION OF THE COMPONENTS

Inspection of Cylinder Heads

After cleaning and decarbonising all parts, the following points should be noted during the subsequent inspection.

(i) Carefully examine valves for any sign of pitting or pocketing and also examine stelliting for cracks. Any signs of picking up or roughness on the valve stems should be smoothed off and polished with super-

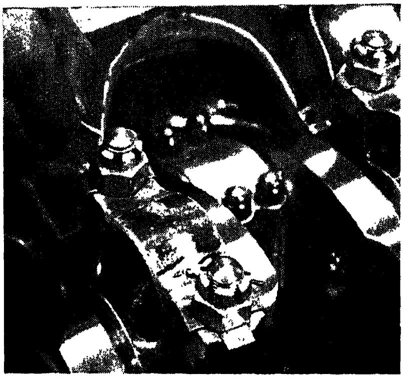


Fig. 25.—SHOWING SPLIT PIN INSERTED IN MAIN BEARING STUD.

Nut must not be slacked back to bring slot in line.

fine emery cloth. If the valve guides or stems are worn beyond the repair tolerances, new parts should be fitted. To remove the valve guides, use the extractor. To avoid damaging the end of the valve guides on replacement the soft drift provided should be used.

(ii) The nut holding the valve rocker bracket should be checked for tightness with spanner, and if slack, tightened up and a new split pin inserted.

(iii) Check the fits of the rocker bush on the spindle. Check up the rocker pads for wear. If the wear is only slight, it can be rectified by stoning smooth, but if the contour of the pad is badly affected, a new pad should be riveted into the rocker. Check up the cup end in the rocker and ball end on the tappet rod for any signs of pitting or undue wear. If pitted, however slightly, replace by new parts. Check tappet rods for straightness.

(iv) Should any cylinder head have been difficult to slide off the cylinder holding down studs when the engine was being dismantled, the holes in the head which take these studs should be checked. These holes sometimes close in slightly at the lower end and should be eased out to the original diameter.

Inspection of Cylinders and Pistons

Cylinders and pistons should now be examined. Check up the cylinder for wear, ovality and scoring of the bore. The piston should be checked for cracks, wear in the gudgeon pin bores, wear in the ring grooves and wear on the diameter. Piston rings should be checked for blowing by loss of spring or excessive gap. If the piston is inserted in the cylinder, the crown can be used for squaring up rings when checking the gap. Fit the piston ring to the piston for checking the ring groove clearance. Before doing this, make sure that the ring grooves are free from carbon. Check up the gudgeon pin for wear and cracks; check the fit in the connecting rod and piston.

Inspection of Connecting Rods

Check up small end bores for wear and ovality, and the small and big end bores together for alignment. Examine the connecting rod bearings for cracks, scoring and adhesion of the white metal. Assemble on crankshaft and check for clearance and side clearance. Do not face off the cap to rectify worn bearings ; fit new bearings.

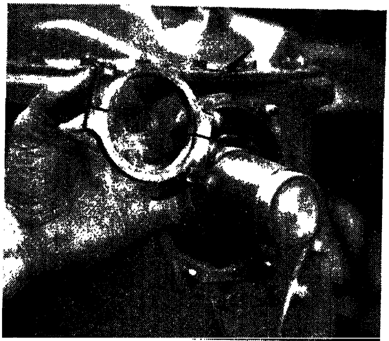


Fig. 26.—FITTING THE THRUST RACE CLAMP NUT IN POSITION (1) (SERIES I).

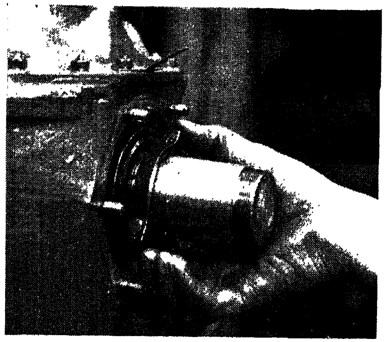


Fig. 27.—FITTING THE THRUST RACE CLAMP NUT IN POSITION (2).

Inspection of Crankshaft

The crankshaft should be examined for scoring, eccentricity, and ovality of the journals and crankpins. If the scoring is deep or if the eccentricity or ovality is outside tolerance limits, the shaft should be

Fig. 28.—FITTING THE THRUST RACE CLAMP NUT IN POSITION (3).

Thrust race clamp nut should be screwed up to thrust race and then tightened a further 1·5 mm. on periphery on shaft to give nip on thrust race to minimise the centrifugal effect on balls in race.

Fig. 29.—FITTING THE THRUST RACE CLAMP NUT IN POSITION (4).

Fig. 30.—FITTING THE THRUST RACE CLAMP NUT IN POSITION (5).

re-ground. The splines where the airscrew fits should be examined for any signs of damage. If slight burrs are apparent they should be stoned off carefully.

Inspection of Main Bearings

The main bearings should be inspected for cracks and scoring. Assemble the bearings in the crankcase and check for clearance on the diameter of the crankshafts. Do not face off the caps to rectify worn bearings. Fit new bearings. Should engine have been in a crash it will be well to check up the boss, if a fixed pitch airscrew has been used, to see that the flange is true with the internal splines.

Inspection of Crankcase and Camshaft

Examine the crankcase for general conditions and any signs of cracking. Check the tightness of the studs, especially the main bearing studs. Check for any signs of flaking of the case or chipped edges on cams and for the general condition of the bearings. Any roughness on the edges of the cams should be removed by careful stoning.

Inspection of Crankshaft Thrust Race

Wash the thrust race very thoroughly and check up for any signs of roughness or pitting of balls on tracks. If defective, however slightly, reject and fit a new bearing. The period of running of the races forms no guide as to their serviceability, as the bearings are adversely affected by condensation if the engine is allowed to stand idle for long periods. Check all gears for chipping, wear or pitting.

If chipping is not very pronounced and is confined to the edges of the teeth, these places can be stoned smooth. Gears worn or pitted very badly should be replaced by new. Check the backlash of the various gears. If the crankshaft gear should require replacing, the crankshaft should be returned to the manufacturers to have this operation carried out.

Inspection of Plain Bearings and Tappets

Check up plain bearings for tightness of fit and condition. Check the fit of the tappets in the guides and examine the condition of the bearing faces; check also the heel of the tappets for flaking, cracks and contour.

Inspection of Induction Manifold

After inspecting the induction manifold for general condition, the gas tightness must be checked as follows. As the manifold is made in six sections, it will be necessary to check each section separately. Blank off the various holes, and pump air into the manifold to a pressure of 20 lbs. per square inch. The manifold must then be immersed in a tank of hot water which will enable any leaks, however slight, to be immediately seen.

RE-ASSEMBLY OF THE ENGINE

After all parts have been examined, faulty parts replaced, and valves ground in, re-assembly can take place in the inverse order to that given for dismantling. The following parts should be replaced by new :—

(i) Dermatine rings between cylinder flanges and crankcase.
(ii) Dermatine rings between tappet guide flange and crankcase.
(iii) Dermatine ring on oil suction pipe in crankcase.
(iv) Copper and asbestos washers between cylinder head and cylinder.
(v) Hallite washers on induction ports.
(vi) Copper and asbestos washers on exhaust ports.
(vii) Graphited hallite washers between cylinder head and valve gear cover.
(viii) Dermatine rings at each end of tappet casing tubes.
(ix) Hallite washers between carburetters and induction manifold.
(x) Diaphragms of fuel pumps.
(xi) Copper and asbestos washers on suction oil pipes.

All oil ways and oil pipes should be thoroughly cleared out, using compressed air if this is available. Oil all component parts of the engine freely during re-assembly.

Re-assembly of Starter Dog in Crankshaft

When replacing the starter dog in the crankshaft, make sure that the front face of the dog is tight against the rear face of the crankshaft.

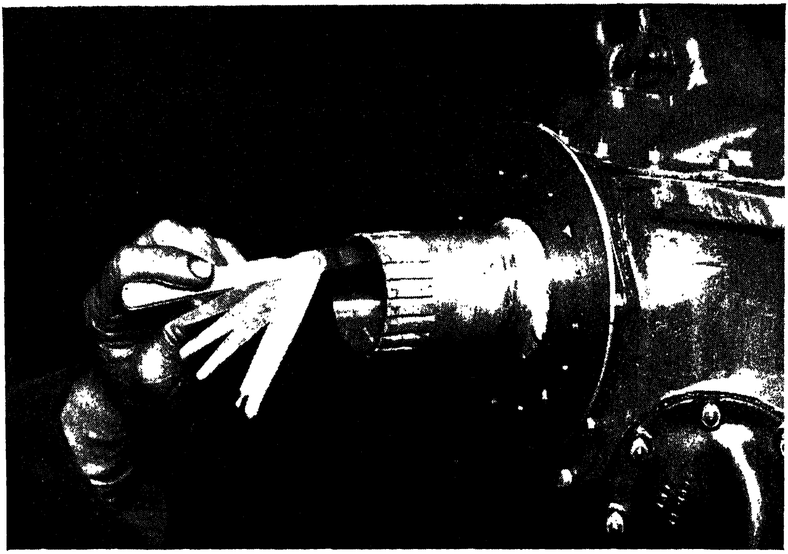


Fig. 31.—CHECKING CLEARANCE OF AIRSCREW HUB KEYS (SERIES I).
Ensure the boss is home on taper and not hanging up on keys.

This should not be pulled into place by the bolt, but should be tapped right home, and merely retained by the bolt.

Re-assembly of Connecting Rods on Crankshaft

When re-fitting the connecting rods to the crankshaft, the big end nuts should be pulled up dead tight, using the ring spanner. The nuts should not be slacked back to get the split pins in; should the slot in the nut go beyond the hole in the bolt the nut should be faced off slightly to bring the next slot in line.

Re-assembly of Camshaft and Tappets in Crankcase

The camshaft should be replaced in the crankcase before fitting the tappets and guides. This will avoid any chance of the tappets falling out while the tappets and guides are being fitted in the crankcase. Dermatine rings should be in place on the tappet guides before these are fitted to the crankcase. Care should be taken that the heel of the tappet sits squarely on the face of the cam before the tappet guides are finally tightened into position. When the camshaft is assembled in the crankcase, it should turn quite freely, and the end float should be checked by inserting feeler gauges between the front and the rear camshaft bearing and the rear face of the shoulder on the camshaft.

Re-assembly of Main Bearings

The main bearing nuts should be pulled up dead tight, using the ring

spanner. As is the case with big end nuts, the main bearing nuts also must be faced off slightly in order to bring the split pin slot in line with the hole. The slot should go beyond the hole in the stud. At this stage it is well to prime the oil connection in the crankcase with oil under pressure to detect possible leaks and to make sure that the leak-holes in the connecting rods are clear. The crankshaft in this condition should turn freely by hand.

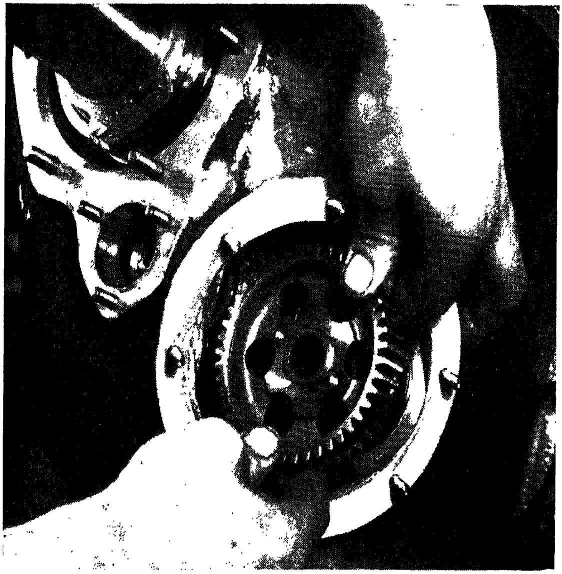


Fig. 32.—SHOWING MESHING OF CAMSHAFT AND IDLER GEAR IN TIMING ENGINE, SHOWING THE FOUR KEYWAY POSITION.

Re-assembly of Crankshaft Thrust Race

During the assembly of the thrust race the two spring steel washers must be fitted so that they present convex faces to the front and rear respectively of the thrust race.

Assembly of New Pistons and Connecting Rods

If any new pistons or connecting rods have been fitted, the corresponding pistons and cylinders should be assembled in the crankcase before fitting the top cover so that the side clearance between the connecting rods and the piston bosses can be checked.

Re-assembly of Airscrew Hub-fixed Pitch

To hold the airscrew hub while tightening up the crankshaft nut, the airscrew can be slipped on the bolts. The box spanner and tommy bar are used to tighten up the crankshaft nut.

Re-assembly of Top and Front Covers

When replacing the crankcase top cover, tighten bolts evenly all round before final tightening. An approved jointing compound should be used on this and other metal to metal joints. Should any new bushes have been fitted in top cover, tachometer drive attachment or idler

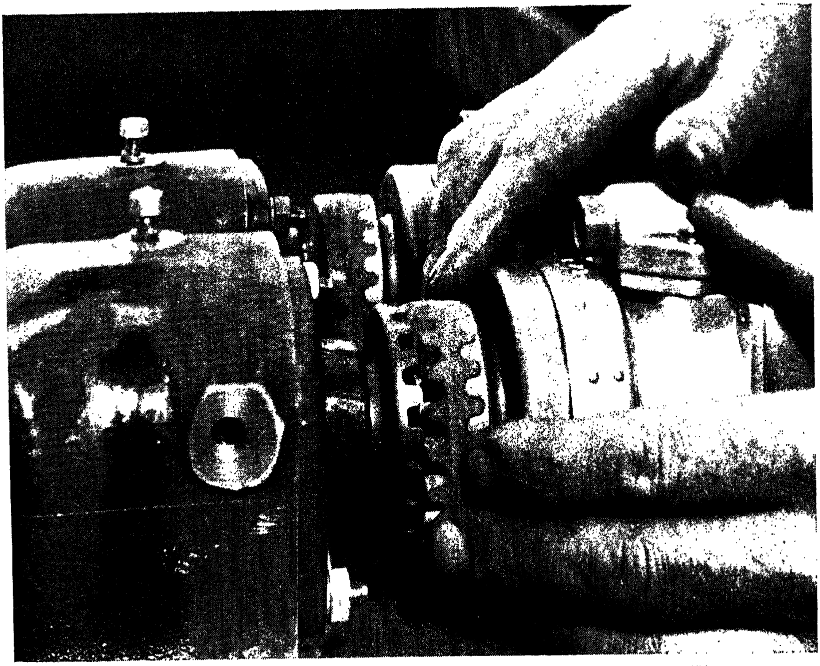


Fig. 33.—FITTING THE SIMMS RUBBER COUPLING TO MAGNETO (1).
Magneto base is slotted to facilitate the fitting or replacement of the flexible magneto coupling.

Fig. 34.—FITTING THE SIMMS RUBBER COUPLING TO MAGNETO (2).

gears, the end float or shafts will have to be obtained by facing off the bushes. When refitting crank-case front cover, centralise this by means of a feeler gauge between front cover and bronze cone before tightening up the nuts.

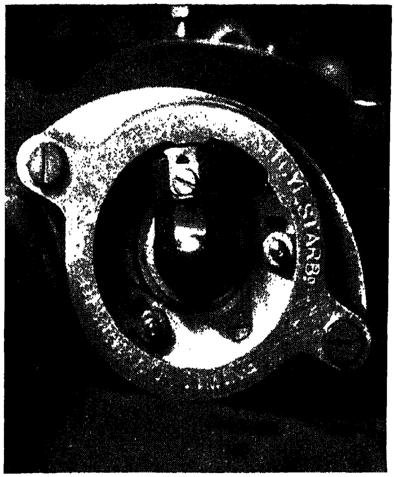


Fig. 35.—Showing special fixture for the timing of the distributor.

Re-assembly of Pistons and Cylinder Barrels

The scraper ring should be housed in the "inner" groove, *i.e.*, the groove farthest from the crown of the piston. It should be noted that the part of this ring which bears on the cylinder wall is fitted towards the crown of the piston.

When refitting the circlips on the gudgeon pins, use the circlip expander. Circlips when fitted must be tight in the grooves in the gudgeon pins. If at all slack, they must be renewed.

Piston ring gaps should be spaced equally apart before fitting the pistons in the cylinder. When replacing the cylinders, use the piston ring clamp to hold the piston rings in place. As the cylinder is pushed

Fig. 36.—Showing the correct method of tightening airscrew bolts (1).

ig. 37.—Showing the correct method of tightening airscrew bolts (2).

Nuts on airscrew bolts should be tightened alternatively and evenly.

over the piston, the clamp will be pushed off the piston, and can be withdrawn before the cylinder is right up in place.

Fig. 38.—SHOWING THE REMOVAL OF FILTER BOWL ON AMAL PUMP ON ENGINE.

Two filter bowls are provided on the Amal duplex fuel pump, which should be periodically removed for cleaning.

Re-assembly of Cylinder Heads

When assembling the cylinder head, use the valve spring compressor and a block of wood inside the cylinder head to hold the valve spring collars down while replacing the collets. While the cylinder heads are being put up, make sure that the cylinder baffle brackets and nuts are in place. The cylinder nuts should be screwed up just sufficiently to hold the heads. The heads should be lined up with a straight-edge against the facing provided for this purpose directly below the port facings. The cylinder heads should then be tightened up by tightening the nuts at opposite corners alternately. Finally the nuts should be screwed up firmly and evenly. It is important that the correct spanner is used for this operation, as using a spanner of too great a leverage will result in a distorted cylinder head, after the head has warmed up during running of the engine. The nuts on the inlet and exhaust manifolds should be tightened up progressively. Do not strain unnecessarily when tightening, as this will only distort the flanges.

Setting of Valve Timing

The valve timing can now be carried out as follows :—

(i) Set the crankshaft so that the exhaust opening position on the

airscrew hub comes opposite the pointer fitted to the crank-case top cover.

(ii) Set valve clearances on No. 1 cylinder to 0·005 in.

(iii) Set camshaft so that clearance is just taken up on exhaust opening position.

(iv) Mesh up the idler gear with both the crankshaft and camshaft gear. When engines are fitted with V.P. airscrews, a timing tool will take the place of the above-mentioned airscrew hub for timing purposes.

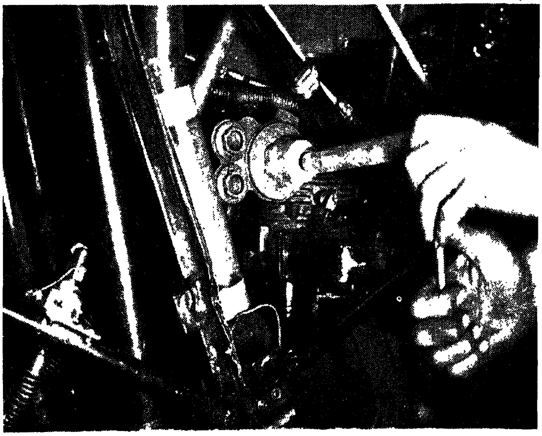


Fig. 39.—REMOVAL OF AUTO-KLEAN OIL FILTER (1).
The Auto-Klean oil filter unit must be removed from its casing for cleaning each 250 hours.

Setting of Magneto Timing

To time magnetos, set magneto advance position on airscrew hub or timing tool opposite pointer on top cover. Set magneto with points about to break with cam ring in full advance position and offer up magneto; turn rubber couplings round until both sets of teeth will enter, one set in magneto coupling and the other set in coupling attached to magneto driving shaft.

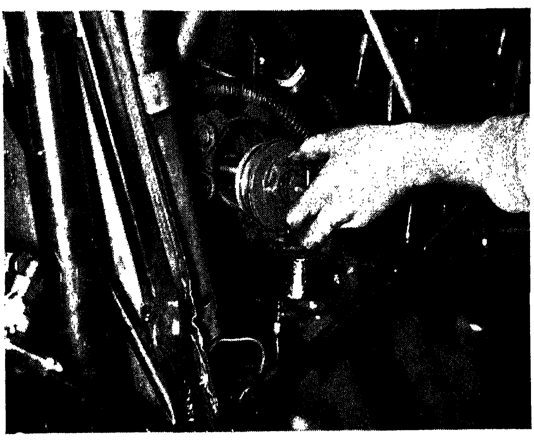


Fig. 40.—REMOVAL OF AUTO-KLEAN OIL FILTER (2).

Setting of Distributor Timing

Set the crankshaft with the piston of No. 1 cylinder in the firing position, *i.e.*, with the magneto contact-breaker points about to break with the cam rings in the full advance position. Bolt the distributor timing tool into position with the screws which normally hold the distributor itself. Bend back the locking

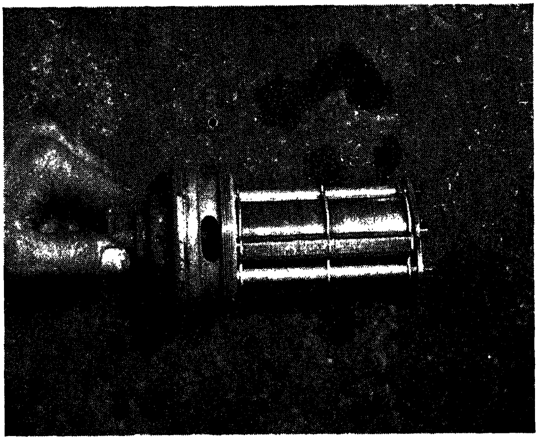


Fig. 41.—THE AUTO-KLEAN OIL FILTER REMOVED

tabs and remove the three small nuts which hold the distributor spindle into position, so that there is 6 mm. from the trailing edge of the motor to the front edge of the lug on the timing tool. It will now be possible to offer the distributor spindle into position. Two lugs will be noticed on the timing tool, one to be used for timing the port, and the other for timing the starboard distributor. Any fine adjustment must be made by use of the slotted holes. Tighten the three nuts and check the distributor timing to ensure that no movement took place during the final tightening. The nuts must then be locked with the locking washers.

Re-assembly of Valve Rocker Covers

When replacing the valve rocker covers the central nut should be tightened up just sufficiently to make an oil-tight joint between the cover and the cylinder head. Each cover should be filled with oil to the indicated level before replacement.

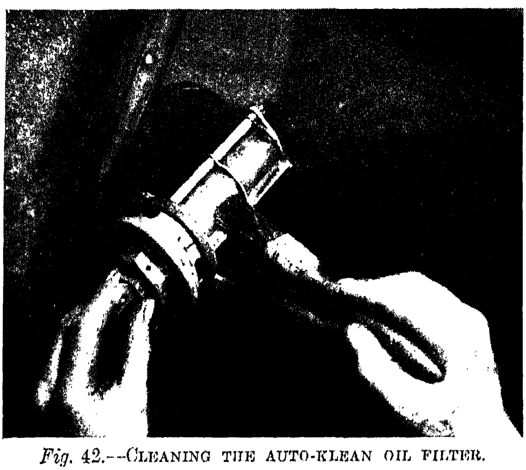


Fig. 42.—CLEANING THE AUTO-KLEAN OIL FILTER.

Re-assembly of Oil Pump Unit

The oil pump unit can now be assembled and fitted to the crankcase. Should any tightness be felt when the pump is rotated it should be rectified before fitting to the engine.

Fitting of New Throttle Spindle Bushes

The old bushes must be pressed out of the carburetter

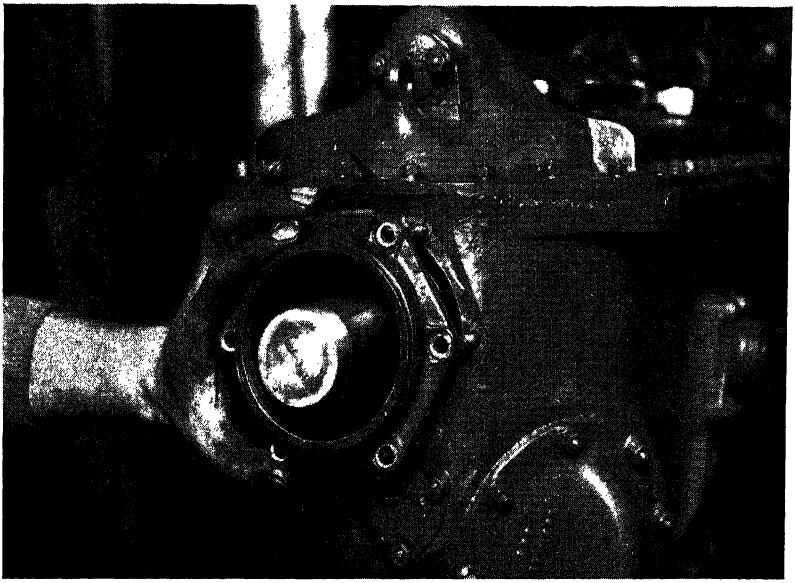


Fig. 43.—SHOWING FITTING AND CENTRALISING OF FRONT COVER (1) (SERIES I).
Front cover should be centralised with the aid of centralising fixture and feelers.

Fig. 44.—SHOWING FITTING AND CENTRALISING OF FRONT COVER (2).

body with a suitably stepped drift, and the replacement bushes similarly pressed into position. When they are correctly in place, they must be reamed right through with a 14-mm. expanding reamer suitably adjusted to allow for wear of the throttle spindle. It is important that both the bushes are reamed at one setting, to ensure alignment of the bores. Should adjustment be necessary to render the throttle valve central in the carburetter - body, or end float adjusted, this

must be effected by skimming the faces of the flanges of the bushes with a facing cutter.

Fitting of New Big End and Main Bearings

As it is essential that the correct working clearance shall be present at the bearings, a check must be made when fitting is complete by the paper strip method, to ensure that the specified clearance has actually been provided. The paper strip should be the length of the bearing, approximately half an inch wide, and of the thickness of the specified minimum clearance new. The strip should be placed in the centre of one half of the bearing. In the case of the connecting rods, the crankpin should be at inner dead centre position. Movement of the journal in the bearing with this strip fitted should be comparatively easy; if it is not, ease the bearing with a scraper as required. If the bearing is slack, insert a paper strip of a thickness equivalent to the maximum clearance new; with this the journal must be a tight fit on the bearing, otherwise the clearance will be beyond the permissible limit.

Fitting of New Rocker Pads

To remove the old pad, file off the peening at the top of the stem of the pad and centre punch mark the stem, taking great care to make the mark central on the stem, and drill a 5-mm. diameter hole down the length of the stem almost to the pad. Next knock out the pad with a stepped drift that is a clearance fit in the hole, taking care to employ only the minimum weight of hammer blows necessary to effect removal of the pad. When fitting the new pad see that the replacement fits snugly with the small keep of the rocker. Rest the pad on a block of hard brass shaped to the curvature of its face whilst peening over the top of the stem. Peen the stem until flush with the surface of the rocker.

Fitting of Sparking Plugs

The sparking plugs are of the bottom seating type, gas tightness being obtained by tightening down on to a charcoal iron washer placed between the bottom of the sparking plug and a shoulder formed at the bottom of the thread in the aluminium bronze adaptor fitted in the cylinder head. Lost or damaged washers must be immediately replaced by new, one of which is supplied with every approved type of sparking plug as supplied by their respective manufacturers. Thus it will be noted that the normal type of C and A sparking plug washer fitted between the cylinder head and the shoulder on the sparking plug is dispensed with entirely, and on no account must be used.

Running in and Testing of Engine

When assembly is complete, engine should if possible be placed on a suitable stand and driven by external means. If a stand and power of this sort are not available, the engine should be fitted to the test bed and run in at 800–900 r.p.m. for one hour before being opened up for the regulation endurance test running.

MAINTENANCE AND INSPECTION OF THE SPERRY GYROPILOT

By WING-COMMANDER G. W. WILLIAMSON, O.B.E., M.C., M.Inst.C.E., M.I.Mech.E., M.I.E.E.

The hours laid down between inspections must be regarded as suggestions only, since R.A.F. units and civilian airline operators will probably be working to their own time schedules.

Prior to flight, the whole of the ground test outlined on page 780, Vol. I., should be carried out; a check should also be made of the quantity of servo oil in the tank; the instrument lights and spare bulbs should also be examined. Only special Sperry servo oil should be used, and a spare tin should be carried.

After 50 hours and before 100 hours, all pipings and fittings should be inspected and tightened or replaced where necessary to stop leaks. Servo packing nuts may also require tightening if there is any leakage. All cables should be free from signs of fraying or wear and should run easily; the springs on the follow-up pulleys should be lightly oiled if dry. Air intake screens on the air relays should be replaced if necessary, as well as those on the vacuum relief valve and gyro control intakes.

The oil in the sump tank should stand at the level of at least three-quarters full; the inspection concludes by making the complete ground test as previously described.

At 300 to 400 hours, most of the accessories should be removed and cleaned; the gyro control units themselves are usually removed and should be tested on the bench in the instrument shop, being overhauled if not satisfactory. Rubber washers inserted for air tightness will probably need to be replaced. The oil sump should be cleaned and the filter at its outlet changed.

At 800 hours, overhaul of many of these components may be necessary; it can be carried out only by highly skilled personnel, specially trained in the overhaul of Gyropilot equipment and authorised to do so, and provided with the special tools and fixtures required for this purpose.

Possible Defects in Working

It is assumed that the original installation of the Gyropilot has been satisfactory, so that any of the defects referred to below may have arisen after a period of service. The apparatus will not function properly unless there is the right vacuum, sufficient oil in the sump and the right oil pressure.

Causes only of each defect are listed except where the remedy is not self-evident.

Poor vacuum under 3 in. of mercury may be the result of the relief valve not being properly adjusted or not seating properly, the vacuum pump having failed, a leak or break in the pipe-line, or a projection such as might be due to the inner lining of the rubber piping having collapsed.

On the other hand, excessive vacuum of more than 5 in. of mercury might be due to clogged filters at air intakes, to the vacuum relief valve being set too high, sticking in the closed position, or dirt clogging the air filter screen at its intake. By removing the screen the valve can be pushed free with the finger ; but if sticking persists it should be repaired or replaced.

Low oil pressure might be due to leaks, bad adjustment or defect in the pressure regulator, clogged strainers, defective oil pump or insufficient oil in system.

Failure of all controls may be due to low oil pressure, low vacuum, engaging lever in OFF position or a broken connection between the engaging lever and the servo unit.

Failure of one control may be attributed to an oil valve sticking, an air relay filter clogged, a speed valve closed or a clogged oil pipe in the servo unit circuit. A defective control unit would also give a similar failure ; and if light blowing and sucking at the air relay intake produces control operation, then control unit defect can be regarded as proved.

Controls hunting may be due to air in the oil system, especially in the servo or to lag in follow-up cable ; or the oil valves sticking, becoming unbalanced or developing backlash. Similar causes will result in the control being jerky, though this may also be caused by a sticking follow-up pulley or cable.

A control which lags only in one direction necessitates the examination of the following possibilities :—

(i.) Follow-up pulley not wound sufficiently.

(ii.) Dirt in balanced oil valve restricting travel in one direction.

(iii.) Oil valve not properly balanced.

(iv.) Unbalanced air cut-off in control unit, due to plugged air passage or unequal clearance between cut-off plates and air nozzles.

Control in one direction only and no control in the other might be due to similar causes, with the addition that one of the filters on the air relay might be clogged. Lagging control in both directions would result from speed valves closed too much, oil pressure low or supply choked, both filters in air relays clogged, low vacuum or servo relief valve set too low.

Acknowledgements are due to the Sperry Gyroscope Company Ltd., Great West Road, Brentford, for all the illustrations in the article in Vol. I., pages 769–781, and for permission to use quotations from their technical literature.

A 1,000-WATT ENGINE-DRIVEN GENERATOR

Generator

BRIEFLY, the Rotax 1,000-watt generator (manufactured for rotation clockwise or anti-clockwise) is an engine-driven four-pole shunt-wound machine developing 1,000 watts at 24 volts when running between 4,000 and 6,000 r.p.m. It is designed to bolt on to a mounting flange of bolt pitch-diameter 6 in., and there are four 0·406-in. diameter equi-spaced holes in the generator flange (Fig. 1). The machine is provided with a cooling jacket; air is fed through a union at the commutator end or at one of the sides. The cable shielding unit, used when making connection with the generator, is carried by the central union to the terminal box. Output varies greatly with engine speed, and a compensated voltage control (regulator N.S.F.F.) is therefore used in conjunction with the machine.

Compensated Voltage Control

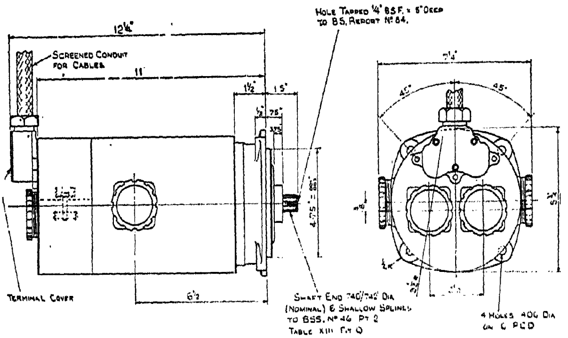
Such a voltage control box (Fig. 2) consists of the generator voltage regulator and cut-out housed together with the series control resistance, a condenser and two high-frequency chokes under one cover.

A single pair of regulator contacts are arranged in such a way as to insert a resistance in the field circuit of the generator during the regulating period, thus controlling the generator output. The resistance is wound on the regulator bobbin so that magnetic influence created by the winding opposes the shunt and series windings, thus causing the contacts to close. The object of such an arrangement is to maintain a high-frequency operation.

Adjustment of the regulator setting, by removal or loosening of the regulator armatures, is not advisable.

The cut-out is provided by an automatic switch connecting battery to generator when the generator is running at sufficient speed to charge the battery, and disconnecting it again when the speed drops too low. The high-frequency chokes, connected in series with the generator and battery, suppress high-frequency interference with the wireless equipment. Located under a smaller cover, and readily accessible, are the terminals, cables being conducted through shielded cable tubes by means of the unions, one to each side of the box. The armature may be removed for contact cleaning, if necessary; settings are effected in much the same way as the regulator setting.

It will be seen that the principles of the compensated voltage control



1.—INSTALLATION DIAGRAM FOR 1,000-WATT GENERATOR.

system are: (1) to ensure a dynamo output independent of the speed at which it is driven; and (2) to maintain the dynamo voltage always in slight excess of the back pressure or voltage of the battery. An extension of these principles is that the dynamo has to deliver, and does, in practice, deliver, only sufficient current to fulfil the load and requirements of the battery adequately.

Generator Installation and Maintenance

The first care of installation should be the coupling; this must be a good fit on the splines, and the hole into which the generator spigot fits must be clear and dirt-free. After the generator has been carefully bolted to its mounting flange, connection is made by way of the screened conduit to the regulator. All wiring should be as short and direct as possible in order to reduce volt drop in the conductors.

Grease or oil of any kind must not be allowed to gain access to the commutator, as any such negligence may result in considerable damage to the commutator; for this reason thin oils should on no account be used in the lubrication of the bearings.

Brushes and brush springs should be regularly inspected. Brushes must not bear on the commutator or bind in their holders, and if worn they should be replaced immediately. Failure to make replacements in time will easily result in burning of the commutator and insulation. Replacement brushes should be of the same material as the originals. If the brush springs have lost their tension they should be replaced. (Brush spring pressure should be 14 ± 2 oz.)

When the commutator is dirty it may be cleaned with a rag moistened in petrol. In reasonably bad cases of commutator burning a cure may be effected by the use of superfine carborundum cloth, all dirt being afterwards brushed off the commutator and brush gear. Very bad cases necessitate setting up on a lathe and the commutator "skimmed," when care should be taken that a minimum cut be set for each operation and that the tool cuts cleanly, leaving a high polish. Intersegment slots should be freed of any turnings; an old hacksaw is a serviceable tool for this purpose.

Failure to generate requires removal of the brush inspection bands

and inspection of the brushes to see that they are contacting properly with the commutator, and that the commutator is clean and free from burns. In cases where the generator is found to be generating, the rest of the circuit should be traced through for break or fault. No indication of a voltage at the terminals may be due to lack of residual magnetism in the pole shoes, and to correct this all brushes should be lifted or the wire to the positive (+ ve) terminal disconnected and the cut-out contacts closed to flash the field, care being taken that the contacts do not stick.

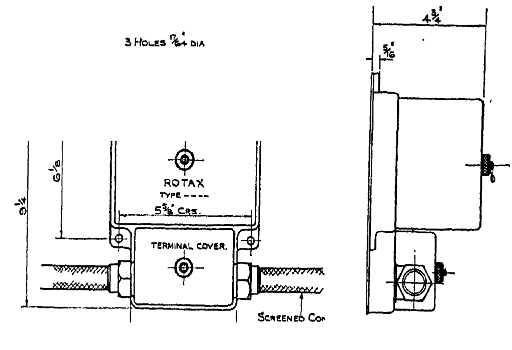


Fig. 2.— FOR

If the field fuse in the switchbox is blown, an ammeter (reading to about 10 amps.) should be placed first in position of the fuse in the faulty generator and then in that of the other generator. If the field current reading of the faulty generator on no-load exceeds (when running between 4,000 and 6,000 r.p.m.) $\frac{1}{4}$–$\frac{1}{2}$ amp. by a fairly large margin, a short may have developed on the field. New field coils can, if absolutely necessary, be supplied for a fitting; but this operation should not be attempted without the use of a pole-shoe expander.

Pole shoes are marked to correspond to their respective tunnels. (Note that pole-shoe screws must be carefully caulked after tightening.) To ensure proper magnetisation of field yoke and pole shoes after assembly, all brushes must be lifted and the field flashed by connection of the positive field terminal to the positive side of a 12-volt battery, momentarily touching the negative side of the battery to the negative terminal of the generator.

A badly burnt commutator may easily lead to loss of voltage, and in such a case the commutator should be skimmed up as described in a previous paragraph.

Armature-winding tests can be carried out from the commutator bars by means of an ohmmeter. A resistance drop between any two windings indicates a short on the windings concerned. Armature and field coils should be tested for shorts, earths and open circuits at the time the generator is dismantled for overhaul. Testing to earth can be made by means of a "Megger"; all parts, when cold, should register infinity. The part under test should be connected by one lead, and the other parts connected to earth. If the fields are to be tested,

one lead should connect to the field leads, and the other lead to the yoke. Parts registering less than infinity when cold should be examined for possible earths. Replacement of parts should be made at once in the event of very low readings.

It is advisable to secure a new armature rather than attempt any rewinding. Removal of the connecting rings in the commutator end frame may cause a short circuit, as these rings are coated with a special insulating varnish, removal of which will allow the interposition of carbon dust.

The brush rocker, on being slackened off or removed, should be carefully set at the neutral (*i.e.*, the pole centre) when replaced or tightened.

Dismantling

In dismantling, the brush inspection bands should be first removed and then the six jacket screws; next to be removed are the field connections attached to the centre terminal lug and to the lug on the connecting ring.

These are followed by the brushes, which should be lifted up and kept at the top of their holders by means of their springs, which may be adjusted to press on their sides. The four tunnel bolts can then be removed and the commutator-end casting slipped off; the armature and end plate are now ready for removal from the yoke. The oil thrower must be removed first—carefully prising up the metal which has been caulked into a shaft spine—before any attempt is made to remove the end plate from the armature.

Next, the four screws holding the ball-race must be removed and the end plate tapped off. Bearings should not be removed from the shaft other than by ball-race extraction, except in the case of the fitting of new bearings.

The brush rocker may be detached from its spigot by unfastening the nut and locking washers.

Re-assembling follows the reverse order to assembly. All parts should be thoroughly cleaned with benzine, and the races regreased before re-assembly.

A DIRECT CRANKING ELECTRIC STARTER

type Rotax Y150B electric starter, as manufactured by Rotax Ltd., for engines up to 450 cu. ins. piston displacement, is designed to crank an engine continuously with the power available from a standard aeroplane accumulator. The starter consists essentially of an electric motor which drives reduction gearing operating an automatic meshing and demeshing mechanism from an adjustable torque overload release.

A pinion, mounted on the armature shaft, drives a crown gear which is integral with a spur pinion meshing with three planetary gears. These gears are mounted on the barrel and run in a stationary gear fastened to the housing; they drive the barrel containing the torque overload release, a spring-adjusted multiple-disc clutch. The barrel drives the externally splined clutch discs, and the internally splined discs drive the spline nut. Threaded within this spline nut is a screw shaft which is caused to advance at the first rotation until the stop nut rests against the back end of the threads. The starter jaw advances with the screw shaft and meshes with the engine jaw.

In order to make the jaw advance into mesh before rotating, use is made of a friction brake consisting of a three-piece friction ring having tips which fit into corresponding slots in the jaw. The brake is held in position on the barrel plate by a spring of predetermined tension.

When the engine starts, the starter jaw is put out of mesh by means of the sloped arrangement of the rear faces of the jaw teeth. The clutch includes a safety device as a precaution against possible damage to the starter in case of engine backfires, and to allow the requisite torque when turning the engine over.

Engine

A clearance of approximately $\frac{3}{32}$ in. should exist between the engine jaw and the starter jaw when the latter is out of mesh. Should the engine not be fitted with a three-tooth jaw, the correct jaw and the attaching parts must be obtained before installation of the starter is attempted.

The type Y150B starter is applicable to engines with standard 5-in. S.A.E. starter mounting flange. Six studs on a 4-in. bolt circle are located in this flange. The starter flange is drilled with eighteen holes, providing various positions 20° apart, in which the starter can be mounted to give the best clearance. The starter will operate equally well in any position.

Battery

The use of an aircraft type non-spillable 12-volt battery is recom-

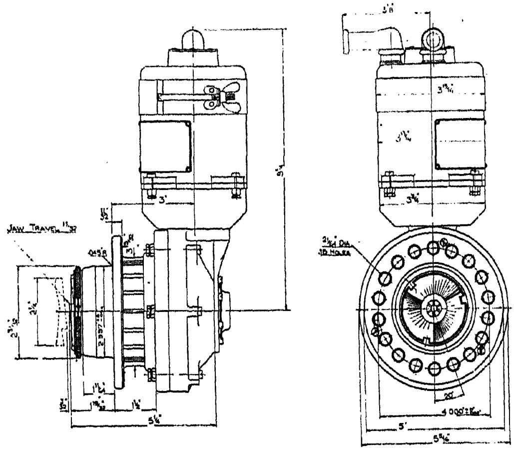


Fig. 1.—OUTLINE OF DIRECT CRANKING STARTER.

mended. The size of the battery depends, of course, upon whatever current is needed in addition to radio, and landing, navigation and instrument lights, etc. A capacity of not less than 25 ampere hours is recommended for single or twin-engine aeroplanes (assuming there is a charging generator on the aeroplane). Where there is not a charging generator—and for four-engine aeroplanes in general—a battery of not less than 40 ampere-hour capacity should be employed. Air Ministry accumulators of the "B" type will be found suitable; these are 12 volt 25 ampere-hour and 12 volt 40 ampere-hour, weighing respectively 30 lbs. and 42 lbs.

The battery should be installed as near to the starter as possible so as to ensure the simplest wiring.

Wiring

A solenoid switch may be employed where the starter is at some distance from the push switch. A push-button located in the cockpit is sufficient for the carrying of the current. Two circuits (battery-starter-solenoid and solenoid-push-switch-battery) constitute the wiring (see Fig. 2).

Main circuit wiring should be to specification 61/036 S.W.G. stranded copper cable, heavily insulated, and all terminals should be entirely covered with insulators. For use in the push-button circuit 35/012 S.W.G. cable is recommended.

The solenoid switch is manufactured in two models differentiated only in the kind of fixing bracket used; either solenoid is constructed to operate at 6 to 7 volts.

Operation

The starter is usually operated with the spark at full advance and the throttle open. Any failure to start readily should be investigated and the cause ascertained in order to avoid running down the battery. The starter jaw must be disengaged by pulling the airscrew through $\frac{1}{3}$ or $\frac{1}{2}$ turn in its normal position (switch off) whenever it is required to unload the

cylinders of their charge. When released, the airscrew may be turned in the opposite direction and then primed again for a new start. A hand starter magneto or booster coil (Fig. 2) will facilitate starting, particularly in cold weather. As a battery will be available in the aeroplane, a booster coil will give better service.

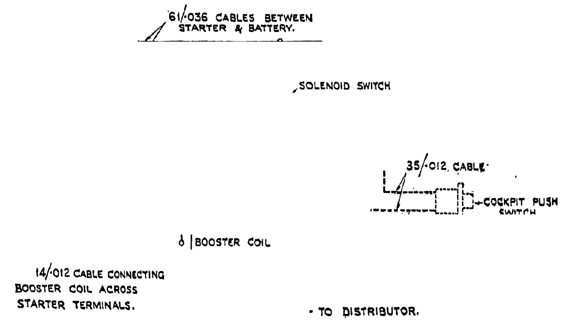


Fig. 2.—CONNECTION DIAGRAM FOR USING BOOSTER COIL IN CONJUNCTION WITH DIRECT CRANKING ELECTRIC STARTER.

Commutator Maintenance

It must be remembered that any oil on the commutator will certainly hinder the operation of the motor and may lead to considerable damage. Starters are already and sufficiently lubricated at the time they reach the user, and they should therefore need no attention for a long period of service. In order to see that they are not bearing on the commutator and not binding in their respective holes, brushes should be inspected at six or seven day intervals. Worn commutators must of course be replaced at once. Failure to make the necessary replacements in time will result in the burning of the commutator and insulation. Brushes for replacement will be best secured from an authorised aeroplane service station; inferior brushes should not be substituted. If, upon examination of brush springs, it is found that they have lost their tension, they should be replaced. (Brushes should be under not less than 20-oz. pressure.)

Fine sandpaper is suitable for the polishing of the commutator; emery cloth or coarse sandpaper should not be used, and the cleaner must ensure that all particles of sand are removed before operating the motor. Should the commutator become rough or burned, the armature should be removed and a light smooth cut taken across its face.

General Maintenance

Failure of the motor to operate may arise through a fault in the solenoid switch or the push-button. If the motor operates with a jumper wire connected across the large terminals of the solenoid switch (making direct contact between battery and starter), then the solenoid or push-button is inoperative.

A good grade of neutral bearing grease (N.E. ball-bearing grease or its

equivalent) is recommended for lubrication of the bearings. Gears and clutch are lubricated lightly with No. 32 Gredag.

Starter clutches should not require altering, as they are carefully set prior to despatch. Setting is determined by the size of the engine on which the starter is to be fitted and used, and it requires special equipment. The clutch setting for the Y150B starter operating on a Gipsy Six or Gipsy Major engine is 200 lbs. ft. In the event of a change in the clutch setting, the starter should be returned to the makers for the necessary adjustment.

Engine oil will retard the operation of the starter so that its performance is unsatisfactory. To prevent any such leakage of oil from the engine crankshaft into the starter housing, an oil seal is incorporated in all starters. In addition to this precaution, and in order completely to cover that part of the starter protruding into the crankcase, a baffle plate is provided to protect the starter from oil splash. Inside the baffle plate at the back of the starter jaw, a leather seal is assembled against the contingency of the oil level's approaching the opening in the baffle plate.

Disassembly

A constructional diagram of the starter is given in Fig. 1. In disassembling the starter the front housing is first separated from the rear housing by the removal of six bolts ; this allows the bevel pinion on the armature to be moved. With the removal of the next four screws the motor can then be taken from the rear housing.

By unscrewing the nut from the operating rod, the starter jaw can be removed, thus allowing the barrel to be removed from the front housing.

If the clutch adjusting nut is to be disturbed it will be necessary to mark its position in relation to the barrel. It can then be assembled again without alteration or interference to the clutch setting.

In the event of returning the starter to the makers for repair or overhaul, and should it happen that the starter has been disassembled, it is of importance to see that the mechanism is thoroughly and entirely cleaned before re-assembling. Tie wire, cotter pins, lock washers and lock nuts must be used where required in the re-assembling of parts.

Service parts are made interchangeable wherever possible, but there are cases where parts, permanently fastened together or requiring special assembly in order to secure the correct alignment, necessitate the furnishing of an entire assembly.

"ECLIPSE" AIRCRAFT ENGINE ELECTRIC STARTER

General Description

FACTORS other than cubic inch displacement—those of compression ratio, engine frictional torque, and climatic conditions, for example—often have considerable bearing on the application of a starter to a particular engine, and it is therefore advisable to consult the makers before installation of a starter is attempted.

The Rotax Eclipse Type E. 160. C. starter consists of an electric motor, reduction gearing, automatic meshing and demeshing mechanism, and adjustable torque overload release, combined with a hand cranking device.

This starter is adaptable for use on engines equipped with 6-in. S. A. E. diameter mounting flange, is operated from a 12- or 24-volt battery circuit (two models for clockwise and two for anti-clockwise rotation being provided), and ensures instantaneous and continuous cranking of the engine.

Installation

Six studs are located on a 5-in. bolt circle in engines having the standard 6-in. diameter S. A. E. mounting flange. Before mounting the starter to the engine, removal of the crankcase plate covering the opening to which the starter is to be applied should be effected. (For installation drawing see Fig. 1.)

The outermost point of the engine jaw must be $1\frac{1}{16}$ in. back from the crankcase flange on which the starter mounts; when the starter jaw is not meshing there must be a clearance of about $\frac{3}{32}$ in. between the engine and starter jaws.

The splined engine jaw mates with corresponding splines on the end of the crankshaft extension, or (in engines using an impeller) mates with splines on a countershaft geared to the crankshaft. The engine jaw is usually held in place longitudinally by a long screw extending through to the crankshaft to which it is threaded and locked by a heavy positive lockwasher.

The bearing used to support the crank extension shaft must in all installations be very rigidly mounted and should be applied to the large-diameter sleeve at the cranking end. A ball bearing is recommended at this point. The extension shaft must be properly aligned and must turn without binding.

Remote control wiring is desirable in outboard engine installations,

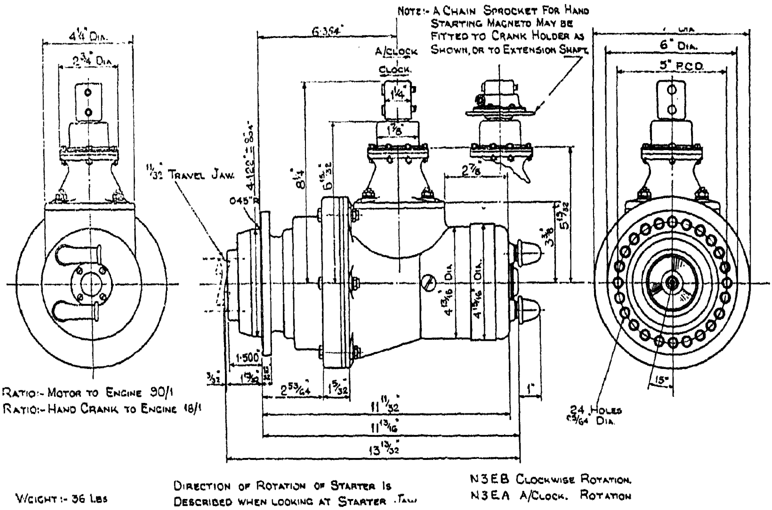


Fig. 1.—METHOD OF INSTALLING DIRECT CRANKING STARTER.

or whenever it is necessary to locate the battery at a distance from the starter switch. The remote control circuit method employs a small light-weight panel-board switch which excites a solenoid switch, which in turn closes the circuit between the battery and starter.

A booster coil is incorporated in the hand or electric starter, the energising of which is effected upon the engaging of the starter switch. The coil can be mounted on the starter or in any place suitably located to the units with which it works in conjunction.

All circuits should be wired with a good grade of heavily insulated stranded copper wire and the length of circuits kept as short as possible.

No specific advice can be given as to the size of battery to be used; this must depend, of course, on the current required by other aeroplane accessories, such as landing lights, navigation lights, radio, etc. A standard aeroplane battery, of the non-spillable variety, 12 or 24 volts, should be used. A generator for battery charging will give a starting system requiring the minimum of attention, a periodical inspection of the amount of distilled water in the battery only being necessary. When a generator is not used, the battery must be carefully checked to ensure a fully charged condition.

Operation

When operated electrically, the closing of the battery circuit to the starter actuates the electric motor, the armature shaft of which is fitted

with a driving pinion. The motor torque is 90 : 1, and is transmitted through a gear reduction unit to the driving barrel containing the torque overload release, a spring adjustable multiple disc clutch. This adjustable clutch is set so that the proper torque or driving power is transmitted to a screw shaft which in turn projects the starter jaw into mesh with the engine jaw.

The clutch is set in such a way as to obviate damage should the starter be engaged to the engine when it is not free to turn over. In order that it should not commence to rotate until it is fully engaged, the starter jaw's engagement with the engine is controlled by a simple mechanism. It may be mentioned that the design of the starter engaging jaw provides for instant demeshing upon starting of the engine.

The operation cycle for manual starting is exactly the same as that of electric starting, with the exception that only a part of the gear reduction is employed. Manual energy is transmitted at a ratio of 18 : 1 through the driving board, and thence the same as with the electrically operated unit.

Starters with the hand-cranking device should be so mounted as to bring the hand crankshaft through the right side of the fuselage (viewed from the rear of the engine). The hand crank is then turned in a clockwise direction (facing the airscrew). For engines equipped with supercharger blowers, in which the starter is applied to a geared shaft, the hand crank is then brought through the left side of the fuselage, and turned in a counter-clockwise direction.

The hand-crank assembly consists of two parts, a crank handle and extension shaft assembly, and is furnished with each starter. The extension shaft assembly is designed to be permanently pinned to the starter cranking shaft, leaving the crank handle to be attached when its use is required.

Engagement and release are automatic, and therefore require no attention. Any failure of the engine to start readily should be investigated, and the cause ascertained at once in order to avoid running down the storage battery or to conserve energy in hand cranking. If it is found necessary to unload the priming charge from the cylinder, the airscrew should be turned one-third to one-half of a revolution in its normal position of switch off so as to disengage the starter jaw. Upon release, the airscrew may be turned in the reverse direction as required, and the engine re-primed for a fresh start. A booster coil is a valuable aid to starting.

Maintenance

Every major engine overhaul should be the occasion for a careful inspection. It is not necessary to lubricate between overhaul periods.

Worn brushes should be replaced immediately, or burning of the commutator and insulation may otherwise result. The required tension

for motor brush springs is 18 to 24 oz. Brush springs should be replaced if less than these figures.

The motor commutator should be kept absolutely free from oil and dirt. Only the finest sandpaper should be used for the smoothing of a rough commutator (emery paper should never be used). Lubricants of any kind should not be put on the commutator or brushes. If the commutator has become pitted, the armature should be removed and a slight cut taken on a lathe across the face of the commutator.

It is important that the leather washer in the baffle plate assembly and the washer between the starter jaw and the screw shaft should be replaced on showing signs of wear or damage.

Friction of the baffle plate oil seal should be checked to ascertain if it has sufficient tension to hold the starter jaw in position so that the jaw will advance forward to mesh with the engine jaw. Jaw travel should be $\frac{11}{32}$ in.

The battery top should be kept clean and the terminals covered with vaseline in order to avoid corrosion.

It is important to note that the clutch cannot be accurately reset, nor should adjustment be attempted, without a special torque-measuring equipment. Extensive experience has indicated that the original makers' setting will remain constant indefinitely.

Dismantling and Assembling

The first process in disassembly is the removing of the four nuts, enabling the hand crank to be detached. The electric motor assembly can be lifted off the front and intermediate housings by the removal of the requisite six bolts.

By successively removing the window strap cover, the four brushes, bearing cap and armature, removal of the armature can be effected. (The armature is lifted out of the opposite end of the motor assembly by removing the oil seal plate.)

Intermediate gear shaft and remaining parts of the intermediate housing assembly can be removed in their respective order by lifting the intermediate housing assembly off the front housing assembly. The driving barrel assembly can be taken out of the front housing assembly by successively removing meshing rod nut, starter jaw and baffle plate assembly, ball adjusting nut locking ring and ball adjusting nut. Torque value of the clutch should be checked at the time of engine overhaul; for this work a torque-measuring device in the form of a prong brake is essential.

The sun gear can be taken off the barrel assembly by removing the barrel nut; the planetary pinions can be removed from the barrel assembly by taking out screws and rings.

Assembly may be accomplished by following inversely the order for dismantling.

Lubrication Chart

Part.	Lubricant.	Manufactured by
Ball Bearings	N. E. Grease	Edgar Vaughan & Co. Ltd., Birmingham.
All Gears .	Gredag .	E. G. Acheson Ltd.,
Plain Bearings	Grease .	Thames House,
Clutch Discs.	No. 223 .	Millbank, London, S.W.1.

When assembling the driving barrel in the front housings it will be found convenient to coat the ball races with grease to hold the balls in place. Sixty balls are needed to each race.

It is unnecessary to set the planetary pinions in any specific position when meshing them with the spur pinion and fixed internal gear.

It is of the utmost importance that the starter be cleaned thoroughly before re-assembling. The interior of the clutch barrel assembly must not be cleaned or washed with petrol, as the discs which compose this part are already lubricated with a special graphite base grease, and removal of this lubricant will seriously affect the operation of the unit.

CLASSIFIED KEY

AERODROME EQUIPMENT

GROUND EQUIPMENT

NAVIGATION LIGHTING

PICKETS AND GRAB HOOK

AIRFRAME CONSTRUCTION AND RIGGING

ASSEMBLY

DESIGN AND CONSTRUCTION

AIRSCREW

CONTROL SURFACES

DESIGN

ENGINE CONSTRUCTION AND INSTALLATION

RUNNING INSTRUCTIONS

SUPERCHARGERS

TOWNEND RING

TYPES

VALVES

ENGINE INSPECTION AND TESTING

MEASUREMENT AND CALCULATION

STRIPPING AND INSPECTION

TEST CURVES

TESTING APPARATUS

TESTING PROCEDURE

ENGINE MAINTENANCE AND OVERHAUL

FUEL SUPPLY

AIRSCREWS

BOOST PRESSURE GAUGES

CARBURETTER INSTALLATIONS

CARBURETTER TUNING

CARBURETTERS AND CARBURATION

INDUCTION SYSTEM

PIPE LINES

PUMPS

TANK

INSTRUMENTS

CONTROL

INDICATOR

INSTALLATION

INSTRUMENT PRODUCTION

MAINTENANCE

MEASUREMENT

PARACHUTES

TESTING AND INSPECTION

INSTRUCTION AND TRAINING

EQUIPMENT

LICENCES

LUBRICATION

GAUGES

INSTALLATION SYSTEMS

PIPE LINES

RENOVATION OF OIL

TANKS

MANUFACTURING ROUTINE

COMPONENT ASSEMBLY

FUSELAGE STRINGER PRODUCTION

FUSELAGES

MAIN PLANE

METAL AIRCRAFT

PRODUCTION SEQUENCE

TAIL PORTION GROUP

WING SPAR AND RIB

WINGS

ENGINE MACHINING

MACHINE TOOLS

METAL WORKING

PRODUCTION OPERATIONS

RIVETING

SOLDERING AND BRAZING

WELDING

WOOD MACHINING

MATERIALS FOR AIRCRAFT CONSTRUCTION

ADAPTABILITY

ALUMINIUM

COPPER

INSPECTION

IRON

PLASTICS

STEELS

TESTING OF METAL

WOODS

PRINCIPLES OF FLIGHT

AIR FLOW

AIRSCREW

GLIDING

SPINNING

WIND TUNNELS

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FREQUENCY BANDS

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